TELEVISION ENGINEERS' POCKET BOOK

THIRD EDITION

Editor: J. P. Hawker

HAWKER

TELEVISION ENGINEERS' POCKET BOOK

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TELEVISION ENGINEERS' POCKET BOOK

Edited by
J. P. HAWKER

Much new information has been added to the enlarged and fully revised third edition of this pocket manual and data book, specially designed to meet the everyday practical needs of all concerned with the repair and maintenance of modern television receivers.

Apart from essential reference data on cathode-ray tubes, valves, television stations and transmission standards, there are extensive sections on the basic circuits used in receivers, on fault finding—including a new trouble tracing chart—and on the alignment of Band I/III receivers. There is guidance on the conversion of Band I sets and a comprehensive list of receiver intermediate frequencies. Colour and transistorized receivers are described.

There are also special sections on servicing equipment, dealing with printed-circuit models and projection receivers, aerials and interference problems.

Both the experienced engineer and the newcomer to service work will find this handy book invaluable for on-the-spot repairs, as well as a most useful addition to his workshop library.

Third Edition

A companion volume to "Radio Servicing Pocket Book".

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TELEVISION ENGINEERS' POCKET BOOK

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PREFACE

Since this pocket manual and data book on television servicing was first published, the establishment of the I.T.A. network on Band III has brought about considerable changes in receiver technique. This new and enlarged edition has therefore been extensively revised to take these and other recent developments fully into account and to provide, in a handy-sized book, the most practical possible summary of basic facts and technical data for day-to-day reference.

In addition to a wealth of useful reference data and information on transmission standards, it contains practical hints on installing, fault-tracing and aligning domestic equipment, together with notes on many special testing instruments introduced during the past few years to facilitate this work; aerial equipment for local and "fringe" reception; matching devices; receiver intermediate frequencies; and maps of the main B.B.C. and I.T.A. service areas. Informative sections are devoted to: interference causes and cures; valve and picture tube data, pin connection and equivalents tables; colour television; colour codes; Band III conversions; printed circuits; projection systems; and the basic circuitry used in modern receivers.

J. A. Reddihough
J. P. Hawker

NOTE TO THIRD EDITION

This new edition has again been enlarged and much fresh material and data added. There are now sections on colour and transistorised receivers while the sections on basic circuitry and fault finding have been revised and expanded; all data sections—including station lists, intermediate frequencies, cathode-ray tubes and valves—have been brought fully up-to-date.

CONTENTS

[SECTION 1]

STANDARDS AND WAVEFORMS

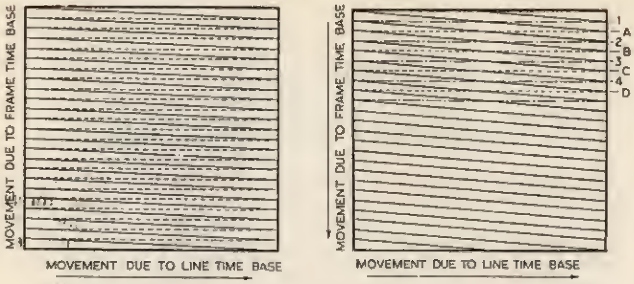
THE basic principle of transmitting pictures over wire or radio circuits by breaking down a series of images into a large number of tiny points, or picture elements; transmitting a signal corresponding to the light value of each element; and then later reassembling an identical series of light points in the same sequence at the receiving end is now so widely understood as to require little detailed explanation. For practical television purposes, it is, however, important to appreciate that although the number of elements into which each picture is broken down provides the final measure of the definition of the picture that can be achieved on any given transmission system, a number of other factors are of importance in determining the fidelity and picture quality of the reproduced picture. These factors include the band-width of the transmission channel, the amount of flicker that can be tolerated, the spot size of the cathode-ray-tube beam at the receiver, contrast, and the linearity of the deflection systems.

It should be noted that, although it is usual to refer to horizontal scanning, in fact the lines are not precisely horizontal, but incline downwards as they proceed from left to right, owing to the influence of the frame deflection, which produces the second dimension of the picture.

Picture-repetition Frequency

The rate at which the process of scanning must be repeated is determined by the following factors: the process must appear continuous to the eye, and must be repeated sufficiently often to give the impression of continuous movement of objects to the viewer, and to avoid noticeable flicker. This process depends for its success on the " persistence of vision " of the human eye, that is to say the fact that the retina retains an impression of an image for an appreciable fraction of a second after the object itself has disappeared. A series of still images presented at a rate of about 10 per second will provide an illusion of continuous movement, but would be accompanied by considerable flicker. If the rate is increased to 25 per second, the flicker will be considerably reduced, but will still be noticeable, particularly where the picture is bright: a repetition rate of 50 per second will eliminate flicker for all practical purposes.

If, however, a television system were to adopt a repetition rate of 50 complete pictures a second, the video frequencies involved in the transmission of a high-definition system would rise to an



(a) (b

FIG. 1.—SCANNING (a) SEQUENTIAL; (b DOUBLE INTERLACE.

extremely high figure, necessitating an excessive transmission band-width. This difficulty has led to the adoption of what is termed "interlaced" scanning: in this system instead of transmitting each line of the picture in sequence, alternate lines of the picture are first scanned, *i.e.*, the lines 1, 2, 3, 4, of Fig. 1 (*b*). The remaining *even* lines (A, B, C, D, etc.) are then scanned. By this means, although only 25 *complete* pictures are scanned each second in the British system, the frame is evenly illuminated 50 times per second. Since, with high definition, it is difficult for the eye to perceive the scanning of the individual lines, the effect is to raise the repetition rate to 50 per second while at the same time keeping the amount of detail and the video frequencies to those for sequential scanning at 25 frames a second. With the British system of 405 lines, these are divided into two frames of 202½ lines each, the half-line playing an important role in automatically controlling the interlace of the receiver scanning system. It is important to note that where, for any reason, the control of the receiver interlace is faulty, the scan will tend to trace out two almost identical paths for both frames, and thus produce a picture in which the lines are clearly visible, and to reduce picture quality.

Picture Transmission

Before discussing the make-up of the British television waveform, it is necessary to consider briefly why the transmission of pictures should be more complex than the transmission of sound.

The transmission from a sound broadcasting station must be capable of reproducing in the receiver the audio frequencies (pitch and harmonic content) of the programme at each moment and also the intensity (amplitude) of the sound; this is done basically by modulating a steady radio-frequency carrier with electrical frequencies corresponding to the audio frequencies, and thus in effect producing a slight variation of transmitter

frequency in the form of sidebands, while at the same time varying the amplitude (voltage output) of the transmitter to correspond with the intensity of the sound.

In picture transmission, since each camera-cell, unlike the microphone, is sensitive only to the average illumination presented to it, and not to detail, it is necessary to indicate the relative brightness of each picture element in turn by means of scanning, and when this differs a high video frequency will automatically occur. Thus, as in sound broadcasting, a radio-frequency carrier is modulated by varying the amplitude of the transmitted wave, in this case to correspond with the intensity of illumination over the range black to white; and this in turn produces sidebands, or frequency variations, whenever a change in illumination takes place. Thus, so far, vision transmission is not basically different from sound transmission, except in the width of the sidebands, which will be much greater for vision than for sound. However, for successful picture transmission, it is also necessary to provide two additional items of infomation that are not required in sound transmission; these are the line- and frame-synchronisation signals, which are required to ensure that the raster on the television-receiver screen is traced out exactly in step with the scanning of the transmitted image by the screen. It is also desirable that the cathode-ray-tube trace be suppressed during the flyback periods. We thus have in effect a number of different types of information that must be radiated by means of a single radio carrier in such a way that each item can readily be separated and made to perform its particular function at the receiving end.

British Television System

The methods adopted in the British television service to convey these items of information may be summarised as follows:

Picture brightness or light value of each picture element is transmitted by amplitude modulation of the carrier, adopting a figure of 30 per cent of peak output to correspond with "black" and the full peak output to correspond with "peak white". This is termed "positive" modulation, to distinguish it from the alternative system (as used in the United States), in which peak output corresponds to "black".

The video frequencies produced by the variation of picture brightness levels form sidebands varying from 0 Mc/s when transmitting an even tone picture (*i.e.*, all black, all white, all grey, etc.) up to approximately 3 Mc/s for a fine network of black and white lines. These video frequencies are separated from the carrier frequency by a detector or demodulator as is done in sound broadcasting.

Synchronisation is effected by using the "blacker than black" portion of the carrier output, the entire output from the transmitter being suppressed (0 per cent of peak output) for greater or lesser periods to provide frame and line pulses. In the receiver these pulses are separated from the vision-intensity signals by

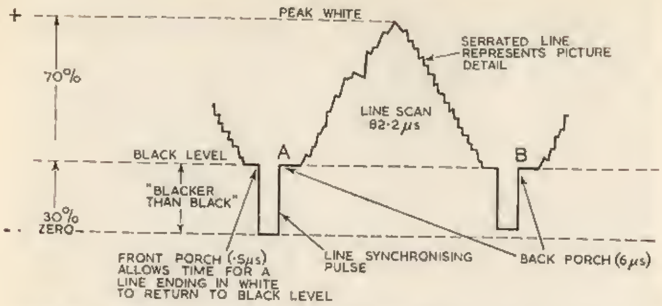


FIG. 2.—SECTION OF TELEVISION WAVEFORM SHOWING LINE-SYNCHRONISING PULSES.

means of an amplitude limiter (usually termed the synchronising separator), and are then further separated into frame- and line-triggering pulses by means of circuits capable of distinguishing between pulses of different lengths.

A section of this basic waveform is illustrated in Fig. 2. The time A–B represents a period of one line (98·7 μS), from which it will be seen that this period is made of 82·2 μS of picture information: a " front porch " (pedestal) pre-line synchronising signal-suppression period of 0·5 μS, to allow time for the carrier to drop to the black level in cases where the line ends on a point of high picture amplitude (*i.e.*, white, or near white); this is followed by a 10-μS synchronising pulse; then a " back porch " or post line synchronising signal-suppression period of 6 μS, to cut off the cathode-ray-tube trace during the flyback period. It should be noted that in these diagrams all pulses are shown with vertical edges; this cannot be achieved in practice, though the leading and trailing edges of the pulses are extremely steep. It is in fact most important that the leading edge of this pulse, which triggers off the line-scan generator, should retain its extremely steep slope in the receiver; otherwise the timing of the scan

TABLE 1.1.—BRITISH TELEVISION STANDARDS

Number of pictures per second	25
Number of frames per picture	2
Number of frames per second	50
Aspect ratio (width/height)	4 : 3 (current) 5 : 4 (original)
Number of lines per frame	202½
Number of lines per second	10,125
Interlacing	2 : 1
Modulation	positive

TABLE 1.2.—BRITISH SYNCHRONISATION CONSTANTS

Constant	*Approx. Time*	*Time in Terms of Line Period*
Duration of line pulse	10 μS	0·1 H
Duration of porch preceding line pulse	0·5 μS	0·005 H
Duration of porch following line pulse	6 μS	0·05 H
Duration of framing pulse	39·35 μS	0·4 H
Space between successive framing pulses	10 μS	0·1 H
Frame suppression period	1400 μS	14 H
Frame-flyback suppression period	1000 μS	10 H
Duration of line period	99 μS	1 H

generator will not be accurate, and a ragged edge to the picture will result.

Frame Pulses

So far we have considered only the line-synchronisation pulses, but the waveform for a double-interlace system must also contain pulses that will trigger off the frame-scan oscillator twice in each complete picture: at the end of the 405th line and halfway through the 203rd line, as well as making provision for the suppression of the flyback trace during the return of the spot from the bottom of the picture to the top. The frame pulses take the form of 8 broad pulses of 39·35 μS duration, each occupying the space of 4 line periods as shown in Fig. 3. This is followed by the suppression of picture information for a further period of 10 lines, to allow time for the frame flyback trace to occur; this is known as the post-frame synchronising suppression period. During this time it is necessary for line pulses to be inserted to maintain the line-scan oscillator at the correct frequency. A similar sequence takes place halfway through the 203rd line period, and picture information is not resumed until halfway through the 217th line. The complete sequence is shown in Fig. 4, (*a*) representing a section of the waveform during any period from the 15th–202nd line period or the 218th–405th line period; (*b*) showing the sequence of frame and line pulses occurring at the end of the 405th line, and lasting until the beginning of the 15th line period of the next picture; and (*c*) showing the sequence from the commencement of the 203rd line

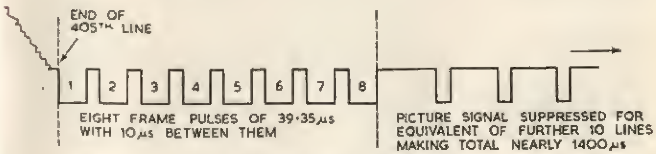


FIG. 3.—FRAME-SCAN WAVEFORM.

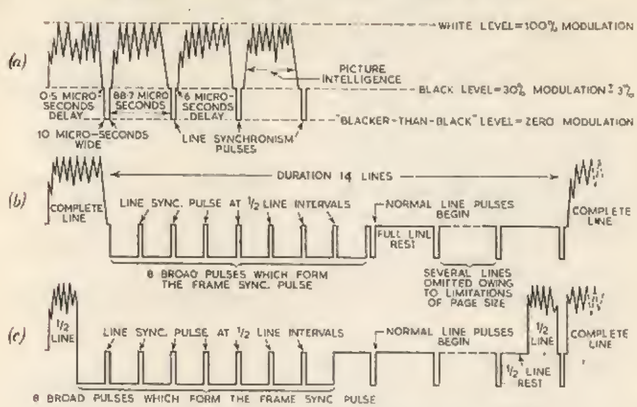


FIG. 4.—LINE AND FRAME PULSES.

TABLE 1.3.—COMPARISON OF TELEVISION STANDARDS

Standard	*British*	*American (F.C.C.)*	*European (C.C.I.R.)*
Total width of channel	5 Mc/s	6 Mc/s	7 Mc/s
Number of lines	405	525	625
Interlacing	2 : 1	2 : 1	2 : 1
Number of lines per second	10,125	15,750	15,625
Number of pictures (frames *) per second	25	30	25
Number of frames (fields *) per picture (frame *)	2	2	2
Number of frames (fields *) per second	50	60	50
Modulation	A.M. positive	A.M. negative	A.M. negative
Black level	30% peak	75% peak	75% peak
Aspect ratio	4 : 3	4 : 3	4 : 3
Carrier	Upper sideband suppressed	Lower sideband suppressed	Lower sideband suppressed
Approx. width of vision channel	3 Mc/s	4 Mc/s	5 Mc/s
Aerial polarisation	Vertical (main) Horizontal (subsidiary)	Horizontal	Usually horizontal
Sound carrier	3·5 Mc/s below vision carrier	4·5 Mc/s above vision carrier	5·5 Mc/s above vision carrier
Sound modulation	A.M.	F.M.	F.M.
F.M. deviation (max.)	—	±25 kc/s	±50 kc/s
F.M. pre-emphasis	—	75 μS	50 μS

* American terminology.

period. It will thus be appreciated that, although we consider the B.B.C. system as having 405 lines, 28 of these lines are lost in so far as the transmission of picture information is concerned, so that in practice an enlarged viewing screen would show a picture made up of 376 complete and 2 half-lines.

Band-width

The video-frequency band-width required to transmit a television picture faithfully with equal vertical and horizontal resolution is given by the formula :

$$\text{Band-width} = \frac{N^2 \times A \times P(1 - S_F)}{2 \times (1 - S_L)}$$

where N is number of lines, A is aspect ratio, P number of pictures per second, S_F fraction of frame period occupied by frame suppression, S_L fraction of line period occupied by line suppression. For B.B.C. standards $N = 405$, $A = \frac{4}{3}$, $P = 25$, $S_F = 0{\cdot}069$, $S_L = 0{\cdot}172$ giving a theoretical band-width of 3·06 Mc/s.

The maximum theoretical definition is reduced in practice by deficiencies in the transmitter and receiver, and the amount of detail which can be seen is further dependent on the brightness and contrast in the picture, and the distance from which it is viewed. In general, the finest detail is seen in the brightest parts of the picture, at high contrast when viewed closely. A very bright picture may, however, cause glare and so reduce the visibility of detail.

Methods of minimising the ill effects of room light, such as "black" cathode-ray-tube screens, neutral or coloured plastic filters and black net over the face of the tube have all been used more or less successfully, and are effective because the light from the cathode-ray tube is attenuated only once when coming through the filters, whereas stray light shining on the tube is reflected back through the filter and attenuated twice.

It is interesting to note that the eye is capable of resolving detail about twice as fine as is observable in a high-quality television picture at a viewing distance of four times the picture height. The actual ratio varies considerably according to the brightness and contrast of the detail, but under no circumstances is the eye called upon to work at its maximum effort when looking at television, so that eye-strain should not result from this cause.

It has been suggested that the correct viewing distance is the least at which the scanning lines are not visible.

There may well be instances where it is not convenient to sit as close as this to the screen, and some surprise may be experienced at the good quality of the picture seen from a greater distance. Another little-understood peculiarity of vision causes small pictures to appear sharper than large ones for the same relative viewing distance, so that sets employing large tubes should have special care taken to ensure the very best definition.

[SECTION 2]

BRITISH TELEVISION NETWORK

The very and ultra high frequency bands allotted in the United Kingdom for television and sound broadcasting are shown in Table 2.1. At present, Band I is used for B.B.C. television transmissions; Band II for the B.B.C. V.H.F./F.M. sound broadcasting network; Band III for the I.T.A. television transmissions. Experimental 405- and 625-line television transmissions have been made in Bands IV and V by the B.B.C., and it seems likely that these bands will be used primarily for television.

For double-sideband amplitude modulation of a 405-line vision transmitter it is necessary to have a bandwidth of at least 6 Mc/s, although the use of asymmetric sideband modulation (see later) reduces this requirement to under 5 Mc/s. Band I, 41–68 Mc/s, is divided into five transmission channels, each shared between a main high-power station and one or more lower-power stations, geographically situated to minimise the risk of interference. The division of Band I is shown in Fig. 1,

TABLE 2.1.—V.H.F./U.H.F. BROADCAST AND TELEVISION BANDS

Band I . . .	41–68 Mc/s	7·3–4·4 m.
Band II . . .	87·5–100 Mc/s	3·4–3 m.
Band III. . .	174–216 Mc/s	1·7–1·4 m.
Band IV . . .	470–585 Mc/s	64–51 cm.
Band V . . .	610–960 Mc/s	49–31 cm.

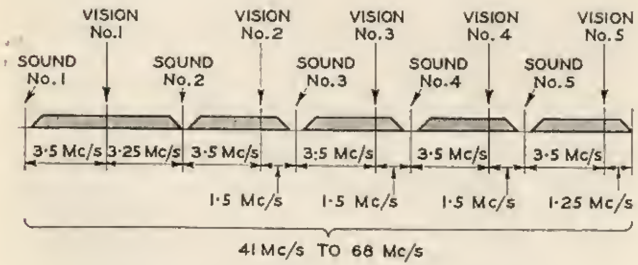


FIG. 1.—FREQUENCY ALLOCATIONS FOR THE BAND I TELEVISION CHANNELS.

FIG. 2.—PROVISIONAL FIELD-STRENGTH CONTOURS FOR THE B.B.C. CRYSTAL PALACE TELEVISION TRANSMITTER.

Receiving aerial height 30 ft. The contours represent expected average values, and variations of as much as 3 : 1 may occur. Owing to local conditions, the boundaries are not rigid: fading may be experienced in difficult locations.

from which it will be seen that the No. 1 channel is of sufficient width to accommodate a double-sideband transmission as used at the original Alexandra Palace station, while the remaining four channels are based on asymmetric transmission bandwidths. In practice, all British television transmissions are now of the asymmetric type.

Each sideband, taken separately, contains all the detail of the modulating wave, and, as it is possible to transmit one sideband

TABLE 2.2.—FREQUENCIES OF TELEVISION TRANSMITTING STATIONS

Channel	*Sound, Mc/s*	*Vision, Mc/s*	*Channel*	*Sound, Mc/s*	*Vision, Mc/s*
1	41·5	45	7	181·25	184·75
2	48·25	51·75	8	186·25	189·75
3	53·25	56·75	9	191·25	194·75
4	58·25	61·75	10	196·25	199·75
5	63·25	66·75	11	201·25	204·75
Band III			12	206·25	209·75
6	176·25	179·75	13	211·25	214·75

FIG. 3.—APPROXIMATE FIELD-STRENGTH CONTOURS OF THE HOLME MOSS TELEVISION TRANSMITTER.

Carrier frequency 51·75 Mc/s. Receiving aerial height 30 ft. The field strength at any given place may differ over a range of ± 10 db from the value indicated by the contours, which represent average values. Considerable fading may be experienced in the shaded area. (The map above, and those shown opposite, are reproduced by courtesy of the B.B.C.)

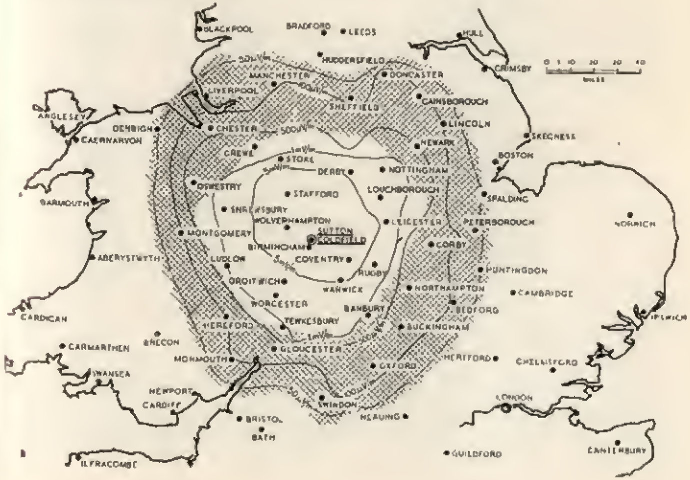
and suppress most of the other, a considerable reduction in band-width results. In British television practice, the lower sideband is used, and the corresponding sound channel is spaced 3·5 Mc/s below the vision-carrier frequency. In view of the low modulating frequencies, double-sideband working is retained for the sound transmission. Thus the complete asymmetric television station, with its high-fidelity sound and vision, occupies a channel of approximately 5 Mc/s. The spacing of the sound and vision carriers of any one station is 3·5 Mc/s, and the spacing of the vision carrier to the next higher channel sound carrier is 1·5 Mc/s.

Field Strengths

Figs. 2–6 show the results of surveys of the field strength of the main B.B.C. television transmitters, made by the B.B.C. research department. In the unshaded areas reception should be good, but in the shaded areas, which are considered to be outside the transmitter service area, satisfactory reception will depend upon

FIGS. 4 AND 5.—APPROXIMATE FIELD-STRENGTH CONTOURS OF THE KIRK O'SHOTTS (ABOVE) AND SUTTON COLDFIELD (BELOW) TELEVISION TRANSMITTERS.

Receiving aerial height 30 ft. The field strength at any given place may differ over a range of ± 10 db from the value indicated by the contours, which represent average values. Considerable fading may be experienced in the shaded areas.



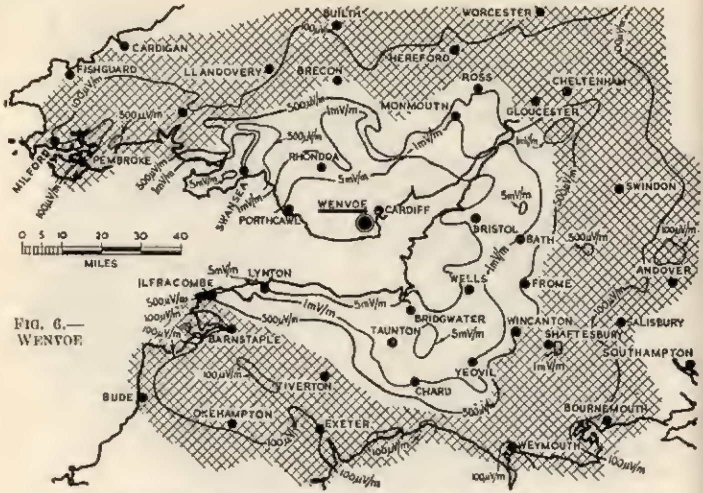


FIG. 6.—WENVOE

TABLE 2.3.—B.B.C. TELEVISION TRANSMITTERS

Channel	*Station*	*Polarisation*	*Vision (kW.) E.R.P.*
1	Crystal Palace	Vertical	200
1	Divis (Belfast)	Horizontal	12
1	Thrumster (Wick)	Vertical	0·3–6·8*
2	Holme Moss	Vertical	100
2	North Hessary Tor (S. Devon)	Vertical	1–16*
2	Rosemarkie (N. Scotland)	Horizontal	1
2	Londonderry	Horizontal	1
2	Whitehawk Hill (Brighton)	Vertical	0·4 max.*
2	Swingate (Dover)	Vertical	0·25–1*
3	Kirk o'Shotts	Vertical	100
3	Rowridge	Vertical	1–32*
3	Norwich	Horizontal	1–10*
3	Blaen-Plwyf (West Wales)	Horizontal	0·5–2*
4	Sutton Coldfield	Vertical	100
4	Meldrum (Aberdeen)	Horizontal	4–17*
4	Sandale (Carlisle)	Horizontal	16
4	Channel Islands	Horizontal	0·25–1*
4	Folkestone †	Horizontal	0·007 max.*
5	Wenvoe	Vertical	100
5	Pontop Pike	Horizontal	12
5	Douglas, Isle of Man	Vertical	0·7–2·8*
5	Peterborough	Horizontal	1–2
5	Orkney	Vertical	4–17*

* Directional aerial. † Low power translator ("Satellite").

Further low-power translator stations, to be completed by 1962, at: Barrow, Berwick-on-Tweed, Enniskillen, Fort-William, Galashiels, Ipswich, Llandrindod Wells, Loch Leven, Oban, Oxford, Pembroke, Sheffield, Skegness and West Cornwall. To be completed by 1964: Forfar, Grantown-on-Spey, Lewis, Pitlochry, Shetland, Skye, Carnarvon, Hastings, Scarborough and Swindon.

local conditions, and fading may occur. As many television receivers now incorporate facilities for the reception of V.H.F./F.M. Band II sound broadcasts, the frequencies and locations of B.B.C. stations are given in Table 2.4.

TABLE 2.4.—B.B.C. V.H.F./F.M. STATIONS

Station	*Home Programme*		*Light Programme Mc/s*	*Third and "Network Three" Programmes, Mc/s*
	Mc/s	*Programme*		
Divis (N. Ireland)	94·5	Northern Ireland	90·1	92·3
Douglas (Isle of Man)	92·8	Northern	88·4	90·6
Holme Moss	93·7	Northern	89·3	91·5
Kirk o'Shotts	94·3	Scottish	89·9	92·1
Meldrum (N.E. Scotland)	93·1	Scottish	88·7	90·9
Norwich (Tacolneston)	94·1	Midland	89·7	91·9
Peterborough	94·5	Midland	90·1	92·3
Pontop Pike	92·9	Northern	88·5	90·7
Llandonna (Anglesey)	94·0	Welsh	89·6	91·8
Llangollen (N.E. Wales)	93·3	Welsh	88·9	91·1
Rosemarkie (N. Scotland)	94·0	Scottish	89·6	91·8
Rowridge	92·9	West of England	88·5	90·7
S. Devon (North Hessary Tor)	92·5	West of England	88·1	90·3
Sandale (Carlisle)	92·5	Scottish	88·1	90·3
	94·7	Northern		
Sutton Coldfield	92·7	Midland	88·3	90·5
Wenvoe	94·3	Welsh	89·9	96·8 *
	92·1	West of England		
West Wales (Blaen-Plwyf)	93·1	Welsh	88·7	90·9
Wrotham	93·5	London	89·1	91·3
Orkney	93·7	Scottish	89·3	91·5
Thrumster (Wick)	94·5	Scottish	90·1	92·3

Further stations, to be completed by 1962, at: Berwick-on-Tweed, Channel Islands, Dover, Fort William, Galashiels, Llandrindod Wells, Loch Leven, Londonderry, Oban, Oxford and West Cornwall. To be completed by 1964: Forfar, Grantown-on-Spey, Lewis, Pitlochry, Shetland, Skye, East Lincolnshire, Enniskillen, Pembroke, Sheffield, S.W. Scotland.

B.B.C. Television Translator (Satellite) Stations

In 1958 the B.B.C. began using a new type of low-power television transmitter, known as a "translator", at Folkestone. This town is typical of small populated areas which are within or adjacent to the service areas of the main B.B.C. stations, but are prevented by hills from obtaining satisfactory reception.

A translator converts the sound and vision transmission frequencies from one channel to another without demodulation to audio and video frequencies which occurs when a normal receiver and transmitter relay installation is employed. This simplification increases the reliability of the equipment, which can therefore be arranged for automatic operation without attendant staff. Because the equipment is small it can conveniently be housed in weather-proof and insect-proof cabinets, thus dispensing with the need for a station building.

Transatlantic Cable Transmissions

The first transmissions of news films via the transatlantic cable were made by the B.B.C. during 1959. This was done by vestigal-sideband modulation of a 5-kc/s carrier with video information of highly restricted band-width. The line definition is first reduced to about 1·75 Mc/s, then only every alternate frame of the 16-mm. film is scanned with 200-line definition by a slow-speed flying-spot film scanner. At the receiving end each of these alternate frames is reproduced as two frames. These measures, though they degrade the picture quality considerably, reduce the band-width to about 450 kc/s. This band-width is then reduced about 100 times by slowing down the scanning process, allowing the resulting video information to be accommodated in the 4,500-c/s band-width of the cable circuit. Thus, using this system, a fifteen second news item takes about twenty-five minutes to transmit over the cable.

INDEPENDENT TELEVISION AUTHORITY

The Independent Television Authority is a public corporation responsible for the provision of television services. It owns and operates television stations, but the programmes they transmit are provided by programme companies. Under the Television Act, the Authority is responsible for shaping, guiding and extending independent television. Its policy is to go forward from the establishment of independent television in selected areas of dense population to the provision of a full national service.

The Authority regulates the system under which the programme companies sell time for advertisements. It also has wide responsibilities under the Television Act for securing proper standards in the programmes; and it is particularly concerned with such matters as accuracy in news, impartiality in matters of controversy, balance in subject matter and the maintenance of good taste. In these, and in all other matters, it maintains close and continuous contact with the programme companies it has appointed.

TABLE 2.5.—I.T.A. TELEVISION TRANSMITTERS

Channel	*Station*	*Polarisation*	*Notes*
8	Midlands	Vertical	200 kW E.R.P.
8	N.E. England	Horizontal	100 kW E.R.P.
9 *	London	Vertical	120 kW E.R.P.
9	Lancashire	Vertical	100 kW E.R.P.
9	N. Ireland	Horizontal	100 kW E.R.P.
9	Devon	Vertical	—
10 *	Yorkshire	Vertical	200 kW E.R.P.
10 *	S. Scotland	Vertical	65–175 kW E.R.P.
10 *	S. Wales	Vertical	200 kW E.R.P.
10	Dover	Vertical	—
11	Isle of Wight	Vertical	100 kW E.R.P
11	East Anglia	Horizontal	200 kW E.R.P.
12	Cornwall	Vertical	—

* Offset.

Stations have also been announced for: Aberdeen (probably Channel 9): Berwick Channel Islands; Inverness; Isle of Man; Solway (probably Channel 11); West Wales.

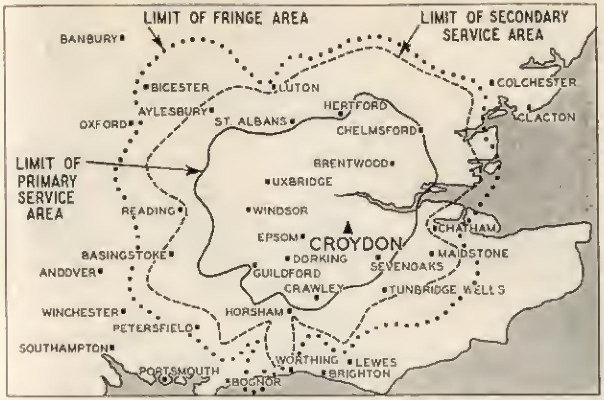


FIG. 7.—COVERAGE OF THE CROYDON I.T.A. TRANSMITTER.
Site height 375 ft., aerial height 175 ft.
—— 2 mV median contour; – – – ½ mV median contour;
. . . . ¼ mV median contour.

Programme Companies for I.T.A.

A.B.C. Television Ltd. (Midlands and North, Saturdays and Sundays).
Associated-Rediffusion Ltd. (London, Mondays to Fridays).
Associated Television Ltd. (London, Saturdays and Sundays; Midlands, Mondays to Fridays).
Granada TV Network Ltd. (North, Mondays to Fridays).
Scottish Television Ltd. (Central Scotland, whole week).
Southern Television (Central Southern and South Eastern England).
Tyne–Tees Television (N.E. England).
Independent Television for South Wales & the West of England, Ltd. (South Wales and West of England, whole week).
Anglia Television (East Anglia).
Ulster Television (Northern Ireland).
Westward Television (S.W. England).
Independent Television News Ltd. (Main news bulletins for all areas).

Location of Transmitters

London Region, Croydon; Midland Region, Lichfield; Northern Region, Winter Hill (Lancashire) and Emley Moor (Yorkshire); Central Scotland Region, Black Hill; South Wales and

FIG. 8.—ESTIMATED APPROXIMATE COVERAGE OF THE SCOTTISH I.T.A. TELEVISION TRANSMITTER.
Site height 850 ft., mean aerial height 1,550 ft.

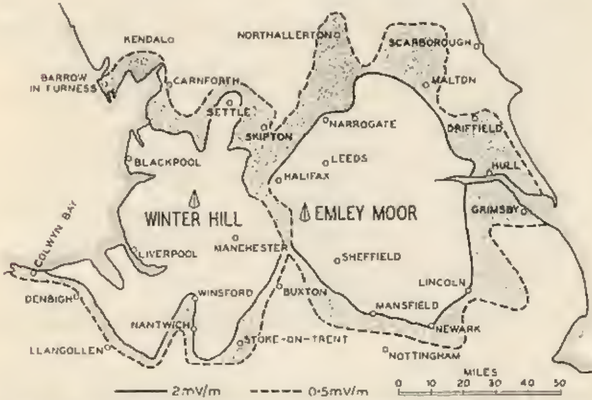


FIG. 9.—ESTIMATED COVERAGE OF THE NORTHERN I.T.A. TRANSMITTERS, WINTER HILL (LANCASHIRE) AND EMLEY MOOR (YORKSHIRE).

FIG. 10.—COVERAGE OF THE I.T.A. MIDLAND TRANSMITTER (LICHFIELD).
—— 2 mV median contour; - - - ½ mV median contour;
. . . . ¼ mV median contour.

West of England Region, St. Hilary; Central Southern Region, Chillerton Down, Isle of Wight; North East England, Burnhope; East Anglia, Mendlesham; Northern Ireland, Black Mountain; S.E. England, Dover; S.W. England, Devon and Cornwall; N.E. Scotland, Aberdeen; Solway (Carlisle area) Hilltop Farm.

Estimated coverage maps for I.T.A. stations are shown in Figs. 7–10.

Future Developments

In May, 1960 the Technical Advisory Committee recommended to the P.M.G. that should Bands IV and V be used for additional programmes, the opportunity should be taken to introduce 625-line standards, basically similar to those of C.C.I.R. (page 14) but with full 8 Mc/s channels (possibly divided 5·5 Mc/s full video sideband, 1·25 Mc/s vestigial video sideband and with sound carrier 6 Mc/s from vision carrier). Such standards would, in these circumstances, eventually be used also on Bands I and III. An early colour service was not recommended. Bands I and III could accommodate three 405-line programmes (5 Mc/s channels) with national coverage or two 625-line programmes (8 Mc/s channels).

[SECTION 3]

BASIC CIRCUITRY

A TELEVISION receiver comprises essentially: (*a*) a means of receiving the picture information and using this to modulate the beam of a cathode-ray tube (often referred to as the picture tube); (*b*) the local time-base oscillators and associated amplifiers to provide saw-tooth signals for deflecting the beam of the picture tube so that it traces out the raster, together with arrangements for keeping these oscillators accurately in step with those used in the original scanning of the picture; (*c*) a sound-channel receiver; and (*d*) the necessary power supplies, including a source of extra high tension (E.H.T.) required for the final anode of the picture tube. In practice, it is possible to use some stages for more than one of these functions, and this helps to keep down the total number of valves required.

Although there has been some trend towards standardisation of the major features of design in modern receivers, there is still considerable variation in circuit details. It should be appreciated that the arrangements used are by no means the only possible ones, but have evolved primarily as a result of the economic competition to provide low-cost but relatively dependable receivers capable of providing a medium-sized picture bright enough for daylight viewing. In some respects—notably in the quality of the sound—few current receivers do justice to the standards of transmission.

Typical Receiver

Fig. 1 shows the block outline of a typical modern receiver. It will be seen that the main sections are as follows:

(1) *A Tuner Unit.* This first amplifies the incoming vision and sound signals on Band I or Band III and then converts them, usually to intermediate frequencies of 34·65 Mc/s vision and 38·15 Mc/s sound. The tuner is generally built as a separate sub-unit and comprises an R.F. cascode amplifier using a double-triode valve such as the PCC84, 30L1, etc., or the higher-slope types PCC89, 30L15, etc., the gain of the R.F. amplifier being governed by an A.G.C. line. The frequency changer stage is almost always a triode-pentode (30C1, PCF80, etc.) with the pentode section used as a mixer and the triode as the local oscillator.

(2) *A Vision Receiver.* The output from the tuner unit is normally fed to two stages of I.F. amplification (sometimes three stages are used for fringe-area reception). These stages have to handle the full band-width of the vision signal, and this limits the possible gain per stage. The first I.F. stage often forms part of

the sound channel, and is generally connected to the A.G.C. line. The second I.F. amplifier operates at a fixed gain. Typical valves in these stages are: EF85, EF80, 30F5, 6F19, 6F23, 6BW7, Z329, etc. The output from the final I.F. stage is fed to a video detector, which may be either a valve (EB91, 6D2, etc.) or a germanium diode (OA71, GEX35, etc.). High-

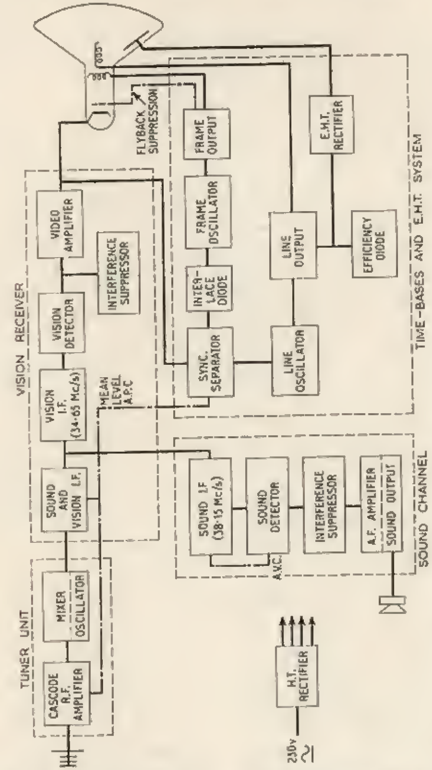


FIG. 1.—BLOCK DIAGRAM INDICATING MAIN UNITS OF A TYPICAL MODERN TELEVISION RECEIVER.

amplitude peaks of ignition or other interference are then usually removed from the signal by means of interference limiter circuits, and the video-frequency signals together with the synchronisation signals are amplified by a video-amplifier, which is usually a single valve, such as the EF80, 30F5, etc.

(3) *A Sound-channel Receiver.* Since the sound transmissions are always spaced exactly 3·5 Mc/s away from the vision carrier,

it is possible for these to be amplified and converted in the same tuner unit as the vision signals. As stated above, it is also common practice for the sound signals to be further amplified together with vision signals in a common I.F. stage, although some makers prefer to separate the sound and vision signals immediately after the tuner unit. There is, however, always at least one I.F. stage used solely for the sound channel. This final I.F. stage is followed by a diode detector (valve or crystal), and the signal then passes through interference-limiting circuits. In some receivers the A.F. signal then goes immediately to a power-amplifying stage; in others a triode-pentode (PCL82, 30PL1, etc.) is used as a two stage A.F. amplifier.

(4) *Frame and Line Time-bases.* The time-bases are required to provide 50 c/s (frame) and 10,125 c/s (line) saw-tooth scanning signals in order to deflect the electron beam of the picture tube both vertically (frame) and horizontally (line) and so trace out the raster. These scanning signals are produced independently by frame and line generators, subsequently amplified and fed to deflector coils mounted around the neck of the picture. To control accurately the generator frequencies, synchronising signals are derived from the incoming vision signals by means of a *synchronising separator* stage, passed through further networks to distinguish between the line and frame sync. pulses (see Section 1), and then used either to trigger directly the generators or—in the case of line "flywheel" systems—to control indirectly a free-running line generator.

(5) *E.H.T. Supply.* All modern direct-viewing receivers derive their source of E.H.T. from the high voltages which are produced across the primary winding of the line output transformer by virtue of the rapidly changing current during the return of the scan stroke to the beginning of the new line (the "line-flyback" period). The peak pulse voltages produced at the anode of the valve are of the order of a few kilovolts and would be too low to be used directly, they are therefore stepped up by means of an overwinding on the primary of the line output transformer. These E.H.T. pulses are then rectified. To provide the damping needed to reduce "ringing" and also to improve the efficiency of the system, an "efficiency diode" is incorporated. As this diode provides a boost voltage which is added to the H.T. for the line output valve (and can be used for other stages) it is sometimes referred to as a boost diode.

(6) *Control Circuits.* Some receivers, particularly those intended for fringe-area reception, incorporate fairly elaborate control circuits for the provision of automatic picture control and flywheel synchronisation.

The circuits used in these various sections will now be considered in more detail.

R.F. Stages

A stage of R.F. amplification is invariably incorporated in a television receiver: (1) to improve the signal-to-noise ratio by

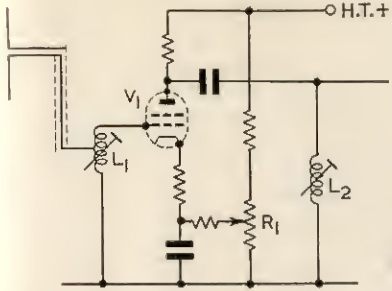


FIG. 2 (*a*).—PENTODE R.F. AMPLIFIER STAGE FOR BAND I RECEIVER.

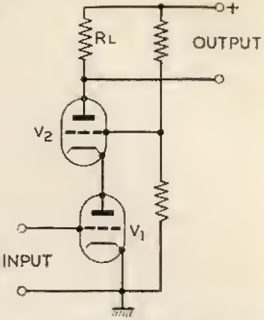
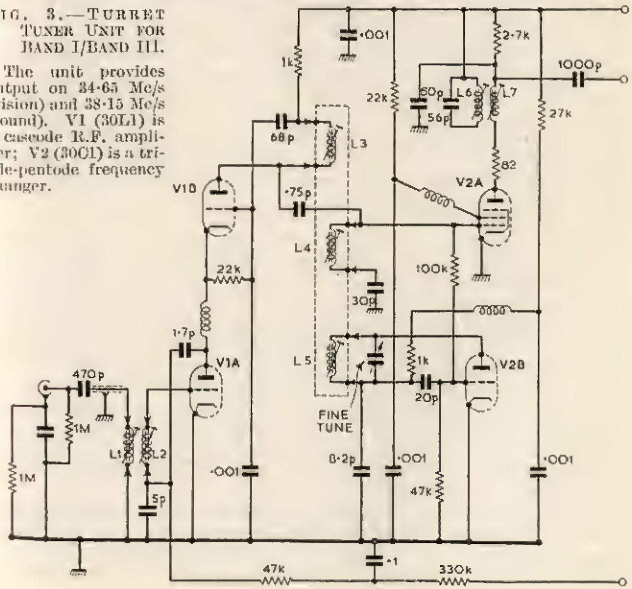


FIG. 2 (*b*).—BASIC CASCODE AMPLIFIER.

amplifying the signal before frequency conversion (the amplified signal will swamp the "noise" contributed by the mixer, which inherently contributes more noise than a straight amplifier); (2) to reduce the possibility of second channel interference and

FIG. 3.—TURRET TUNER UNIT FOR BAND I/BAND III.

The unit provides output on 34·65 Mc/s (vision) and 38·15 Mc/s (sound). V1 (30L1) is a cascode R.F. amplifier; V2 (30C1) is a triode-pentode frequency changer.



other forms of spurious response; (3) to isolate the oscillator from the aerial and so minimise radiation which could interfere with other receivers or services.

Conventional pentode R.F. amplifiers of the type shown in Fig. 2 (*a*) were widely used before the advent of Band III. L1 and L2 are tuned by a slug and the stray capacitance. R1 is a pre-set gain control "sensitivity" to avoid overloading the following stage in areas of high signal strength.

With the higher frequencies of Band III it is very difficult to design a conventional R.F. amplifier that will give equal gain throughout the necessary tuning range. For this reason, a circuit known as the series-connected cascode has been adopted in Band I/III receivers. The basic form is shown in Fig. 2 (*b*), where two triodes are seen to be connected in series. The second triode may have its D.C. grid voltage fixed by means of a potentiometer and, acting as a cathode follower, holds the anode voltage of V1 very nearly constant. The anode current of V1 still flows in the load formed by the cathode input impedance of V2, but, with the anode voltage constant, the behaviour is that of a pentode having no screen current and no partition noise. From the signal point of view, V2 is a grounded-grid triode, is stable and produces gain with a good noise factor. V1 produces little gain, due to the low load, but has a high input impedance—allowing a good matching circuit, which helps the noise factor—and does not essentially require neutralisation.

On the higher frequencies the noise factor is improved by neutralisation, and this is often incorporated; for example, by the bridge circuit formed by the 1·7-pF and 5-pF condensers in Fig. 3. Special double triode valves have been developed for this application, including high-slope valves, using what is known as "frame grids". These have a special form of grid construction which provides a high degree of electron control.

Mixer and Local Oscillator

Various frequency conversion circuits were used in Band I receivers: most common was the pentode mixer, either with a triode oscillator or in the self-oscillating mixer (see Fig. 4), but triode and hexode mixers were also used. In Fig. 4 the oscillator coil L3 is connected between the control and screen grids. The signal is fed to a tap on the oscillator coil, which is at zero-oscillator potential. L4 is the anode load tuned to intermediate frequency, and in the particular circuit shown R2 acts as a damping resistor to secure adequate band-width, since the input damping of the next stage is not so great as at the higher signal frequency. The "intermediate frequency" output includes both the picture and sound information, and is thus really a band of frequencies some 4 Mc/s wide.

Since the introduction of Band I/III tuners, a triode-pentode valve with internal screening between the sections has been almost invariably used. The triode oscillator output is lightly coupled to the grid circuit of the pentode mixer. The oscillator in

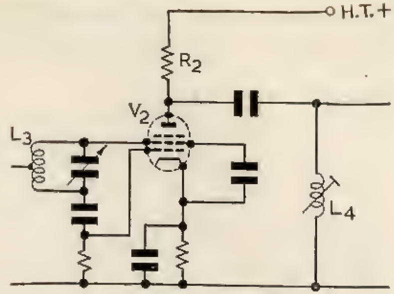


FIG. 4. — FREQUENCY CHANGER USING A SELF-OSCILLATING R.F. PENTODE.

most turret tuners functions by means of a feedback coil, but the Hartley circuit is often used in incremental switch tuners (see "Channel Selection"). The main problem associated with the oscillator stage is that of obtaining sufficient stability to avoid the need to readjust the fine tuning control except when changing from one channel to another (in some designs the fine tuning control has been eliminated). This requires that the oscillator drift should not exceed about ± 100 kc/s. Stability is achieved partly by having a relatively large capacitance across the oscillator tuning circuit, which thus swamps the changes in valve capacitances caused by a change in temperature, and partly by the use of negative-temperature coefficient capacitors, chosen to compensate for the temperature coefficients of the other components.

Most modern receivers have intermediate frequencies on, or close to, the B.R.E.M.A. recommended frequencies of 34·65 Mc/s vision and 38·15 Mc/s sound. These figures were chosen to provide maximum freedom from interference from harmonics of local stations, direct breakthrough, second channel, etc. Formerly much lower intermediate frequencies were popular (see Section 13) on account of the higher gain per stage.

Channel Selection

The advent of Band III transmission brought about the necessity of manual channel selection by the set owner. Some early Band I/III tuners used a simple switch system for selecting between three sets of aerial, R.F. and oscillator coils. The most common system in current use, however, is the turret tuner, which provides for fitting twelve sets of aerial, R.F. and oscillator coils on a rotating drum so that the appropriate set of coils for the channel required can easily be rotated into circuit. Alternative systems also currently used are incremental switch and permeability tuners. In the incremental switch type successive additional inductances (small coils of a few turns) in the aerial, R.F. and oscillator circuits are brought into circuit by means of a rotary wafer switch. In the permeability type the aerial,

R.F. and oscillator cores are ganged together for common adjustment. Typical turret and switch-tuner circuits are shown in the Alignment Section.

Intermediate-frequency Stages

The I.F. stages are required not only to provide the bulk of the gain needed to build up the aerial input signal voltage (from about 20 μV upwards) so as to provide an output from the video detector of about 2 volts peak white but also to separate the vision and sound signals and to provide protection against adjacent channel interference. The band-width of both the vision and sound I.F. response must be sufficient to allow for oscillator drift to accommodate double-sideband sound bandwidth of about 20 kc/s and single-sideband video information up to 3 Mc/s. Since the gain of a valve varies inversely with the band-width, it is easier to obtain the necessary gain on the sound channel than on the vision channel. In older models it was common to obtain the necessary vision band-width by "stagger" tuning the tuner circuits, each circuit being tuned to a slightly different frequency. Modern circuits, however, more often use band-pass coupling transformers, often to quite complex design.

Fig. 5 shows a modern vision I.F. strip designed for use with high-slope frame-grid valves capable of providing extreme fringe reception with only two I.F. stages. The circuit associated with L2 is an adjacent-channel trap and would be tuned to 33·15 Mc/s. Both sound and vision signals appear across the anode load L3a. The sound signals are then fed off to the sound I.F. stage and prevented from reaching the grid of V2 by means of a bridged-T filter formed by L4, the two 27-pF condensers and the 8·2k resistor. This type of filter sharply rejects a single frequency

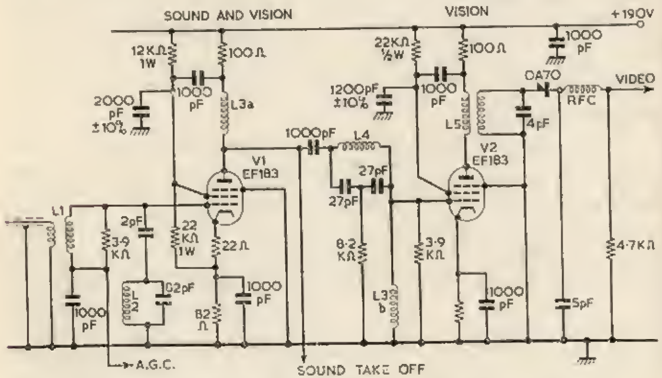


FIG. 5.—I.F. AND DETECTOR STAGES WITH "FRAME-GRID" PENTODES.

without appreciably distorting the response curve on nearby frequencies. In this circuit the stages are neutralised by means of the 10% common screen/anode decoupling condensers. I.F. stages using lower-slope valves are seldom neutralised.

Considerable variation in the inter-stage coupling and in the sound-rejection traps occurs between different models, and some of these differences can be noted from a study of the representative receiver circuits provided later in this section.

Detector and Video Amplifier

After the I.F. stages come the detector and video amplifier; Fig. 6 is typical. The diode load R_7 is only 3–5 k: the effective load at, say, 3·5 Mc/s will not be sensibly lower than at, say, 25 c/s, though it is shunted by stray capacitance whose reactance falls with increase of frequency. Without considering any special compensation circuits, the response will be 3 db down at the frequency for which $2\pi fCR = 1$. A load resistance of 5 k therefore postulates stray capacitance of only 9 pF. L_9 is an I.F. filter, and if the stray capacitances at each end (shown dotted) are considered, it approximates to a conventional low-pass filter. Here, too, a high I.F. simplifies filtering, as it is more remote from the upper video frequencies. This video stage, giving a negative output, drives the cathode of the cathode-ray tube.

To improve the high-frequency response, "top-lift" circuits may be incorporated in the video amplifier: an inductance is

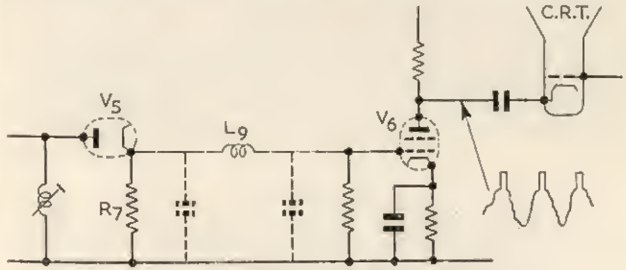


FIG. 6.—DETECTOR AND VIDEO AMPLIFIER.

included in the (resistive) load and chosen to resonate with the stray capacitance at a frequency above (*e.g.*, $\sqrt{2}$ times) the highest required frequency. This maintains the load impedance—and hence the gain—up to a higher frequency than for an uncorrected circuit. The inductance is given by $L = p.CR^2$, where p has a value 0·3–0·5.

Many receivers incorporate a cathode follower in the video output stage. This became popular because of the greater output required when the 21-in. picture tube came into common use. Whilst a cathode follower stage has a voltage gain of less

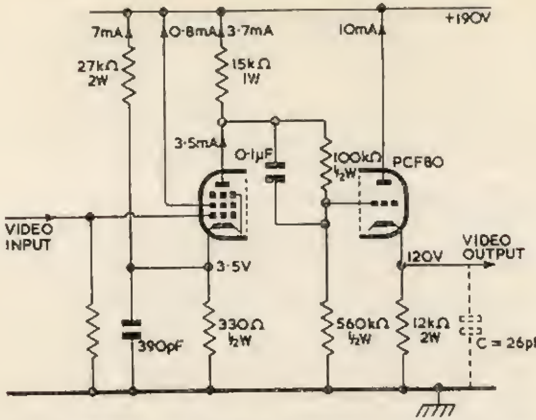


FIG. 7.—VIDEO AMPLIFIER STAGE INCORPORATING A CATHODE FOLLOWER. (*Courtesy Mullard, Ltd.*)

than 1, the inclusion of such a stage isolates the first video stage from the stray capacitances into which it would otherwise have to work, thus enabling the gain of the first video stage to be increased whilst maintaining band-width. Such stages are also found in 14- and 17-in. models, to effect a saving in the number of I.F. tuned circuits required. Gains of up to about 22 are possible with a two-stage video amplifier such as that shown in Fig. 7, whilst a gain of about 11 was the maximum possible in a single pentode stage with full bandwidth; recently however valves giving greater gains in a single stage have become available.

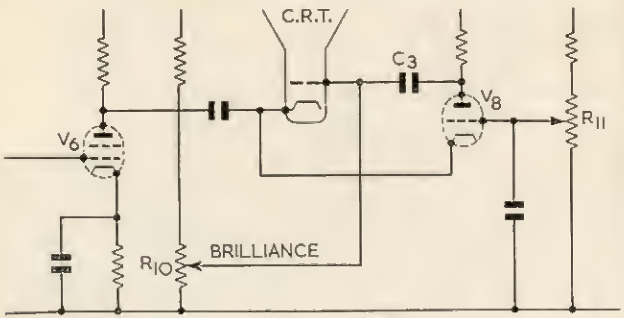


FIG. 8.—VISION INTERFERENCE SUPPRESSION CIRCUIT USING SPOT INVERSION.

Interference Limiters

Interference limiters, chiefly to reduce ignition interference, are essential. They fall broadly into two groups, one in which the gain of some valve is sharply reduced during the interference pulse (Fig. 9), and the other in which normally white-going interference is inverted to appear as black (Fig. 8).

V7, a low-impedance diode, shunts R_8, and is normally non-conducting with its anode at a potential corresponding to peak white. When a large-amplitude interference pulse arrives at V6 grid, its anode is driven more negative than for peak-white, and V7 cathode is carried with it, making V7 to conduct and to shunt R_8, thus reducing the load and gain of V6 for the duration of the interference.

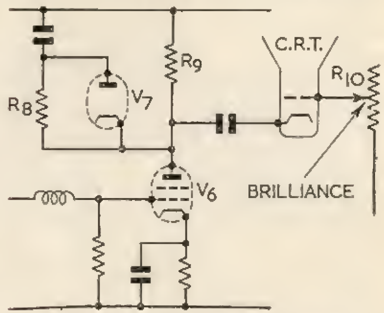


FIG. 9.—VISION INTERFERENCE SUPPRESSION CIRCUIT. V7 CONDUCTS DURING INTERFERENCE PEAKS.

In the spot inverter V6 is again the video valve, and its output, as well as driving the cathode of the cathode-ray tube, is fed to the cathode of V8, a triode whose grid is suitably biased by R_{11}, so that at peak white V8 is just cut off. Any impulsive noise of greater amplitude than this lowers the cathode potential of V8 so that it conducts, passing through C_3 an amplified signal to the cathode-ray tube grid, and so producing a black spot which is generally less noticeable than a white one.

SOUND CHANNEL

The general design features of the sound channel up to the detector stage do not differ greatly from the circuits used in the vision channel, except that the inter-valve coupling tends to be less complex. The total gain required is much the same as that for the vision signal—of the order of 100 db (100,000 : 1). The majority of this gain is supplied by the I.F. stages.

The band-width of the sound channel as transmitted will be of the order of 30 kc/s, representing the double-sideband transmission of audio frequencies up to 15 kc/s, but the receiver band-width requires to be much greater than this figure would suggest. This is partly in order to overcome the effect of oscillator drift, which may amount to some 100 kc/s, and partly to help in the suppression of impulse interference from car ignition systems and electrical equipment. A broad response of the order of 500 kc/s will mean that the interference pulses can be reproduced

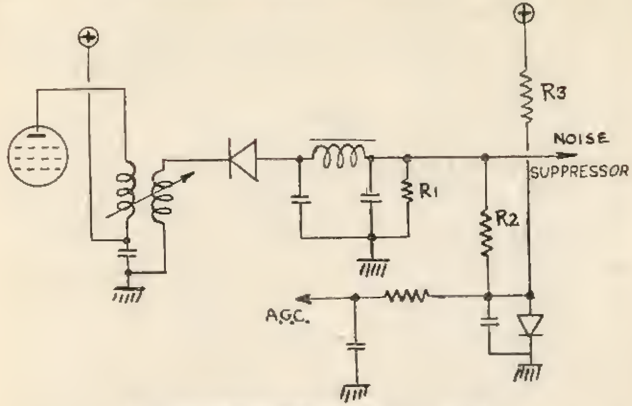


FIG. 10.—SOUND DETECTOR AND A.G.C. CIRCUIT.

at the detector without undue lengthening, and this will make for more efficient interference suppression. With a broad-response curve it is sometimes difficult to prevent low-frequency vision-signal components from entering the sound channel (for example, the frame synchronising signals may be reproduced as 50 c/s hum), particularly where the user does not adjust the fine tuner control accurately.

With the high sound I.F. of modern receivers—usually 38·15 Mc/s—I.F. stage gain with conventional high-slope pentodes tends to be limited to about 30–40, in order to ensure stability. Considerably higher stage gains can be obtained with frame-grid valves, although it may be necessary to use some form of neutralisation to maintain stability.

It is common practice to control the gain of a sound I.F. stage by an A.G.C. voltage obtained from the detector stage. However, in some designs no separate sound A.G.C. system is incorporated.

The Detector

As in the case of radio receivers, the diode detector has long been popular in television-receiver designs. The value of the load resistance will, however, be much lower than in radio practice, and the I.F. filter will consist of chokes and very small condenser values (10–20 pF) in order to prevent the undesirable integration of interference pulses. The use of germanium crystal diodes has to a large extent ousted the thermionic diode on the counts of low cost and low self-capacity.

An A.G.C. potential may be taken from the detector load, a suitable arrangement being shown in Fig. 10, in which a delay diode is incorporated. The detector circuit has, of course, to produce a signal sufficient to cause a current flow in R2 equal

to the current normally flowing from the H.T. line through R3 and the delay diode before the delay is overcome. Delay circuits are by no means universal, and a compromise method is to apply only a part of the detector D.C. component to the A.G.C. line. Whichever method is used, it is necessary to reduce the impedance of the A.G.C. line to the minimum so that blocking does not occur in I.F. grid circuits connected to it.

Interference Suppression

The level at which the detector operates is determined largely by the performance of the audio-output stages, which follow it, and also by the circuit used to provide suppression of impulsive interference. While audio amplifiers to provide the required output (normally 1–2 W) can easily be designed to accept very low inputs, the noise-suppression circuit operates best at fairly high levels. It is placed immediately after the detector, so that the need for wide band-widths can be dispensed with after the interference has been reduced sufficiently, and it is not difficult to operate the detector to provide a demodulated output of 5–10 V peak-to-peak (80 per cent modulation).

One of the most successful noise-suppression circuits * is shown in Fig. 11. Resistances R1 and R2 are of the order of megohms, so that a steady current of, say, 50 μA flows through the diode. The condenser C is a critically large value chosen so that the time constant formed with R2 is just capable of being charged and discharged by the current flowing through the diode at the highest audio frequencies it is desired to reproduce. From the waveforms it is apparent that at audio frequencies the cathode of the diode follows the anode. If, however, a negative-going interference pulse of very short duration appears, the diode will immediately cut off and the cathode circuit will commence to discharge. Before any great change has taken place, the pulse ends and the audio signal reappears at the output bearing only a small triangular "pip" instead of the original large pulse. The further smoothing is provided to smooth out this remaining pip.

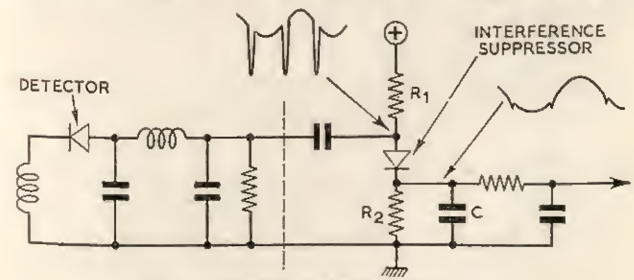


FIG. 11.—INTERFERENCE SUPPRESSION CIRCUIT.

* British Patent No. 605,206.

It is now possible to see why so much attention has been given to preserving the shape of the interference pulses and to the prevention of blocking.

Audio Output

While it can be said that any good-quality audio stage will suffice the needs of the television sound channel, it is perhaps worth remembering that quite a lot of effort has gone into the production of a very high-quality signal at the output of the detector and noise-suppression circuits. Although reproduction may be marred in the fringe areas by weak signals and continuous interference, and the main attention of the audience is concentrated upon the picture, there are many occasions when the reproduction of the full quality will be worth while. Apart from this, it is probably true to say that there is no great need for as high an output as is produced by a radio receiver, since the viewers will normally be relatively close to the loudspeaker.

If a noise-suppression circuit of the type described above is used, it must be made independent of any negative feedback arrangement which may upset its operation.

V.H.F./F.M. Reception

Many television receivers now incorporate facilities for the reception of Band II V.H.F./F.M. sound broadcasting stations.

One of the simplest methods is to fit three additional sets of coils in the turret tuner, tuned to the local Home, Light and Third channels, and to arrange to switch into circuit when required an F.M. discriminator, usually a ratio detector, in place of the television A.M. sound detector. H.T. and heater supplies to the picture tube are switched off during F.M. reception to extend its life. Similarly, the time-bases and sometimes the video strip may be taken out of service. A typical arrangement for a combined A.M./F.M. detector stage is shown in Fig. 12. V1A acts as a conventional sound demodulator when the set is switched

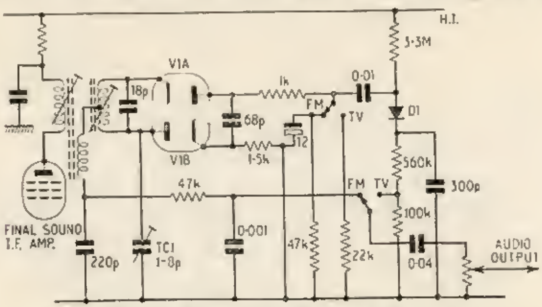


FIG. 12.—DETECTOR STAGE OF A RECEIVER WITH FACILITIES FOR V.H.F./F.M. RECEPTION.

to "TV", and V1B is then out of circuit. On "F.M." V1A and B form a ratio detector with amplitude changes stabilised by the 12-μF electrolytic condenser, and maximum A.M. rejection is obtained by adjusting the balancing trimmer TC1. D1 is an interference limiter diode on "TV", but is switched out of circuit during F.M. reception.

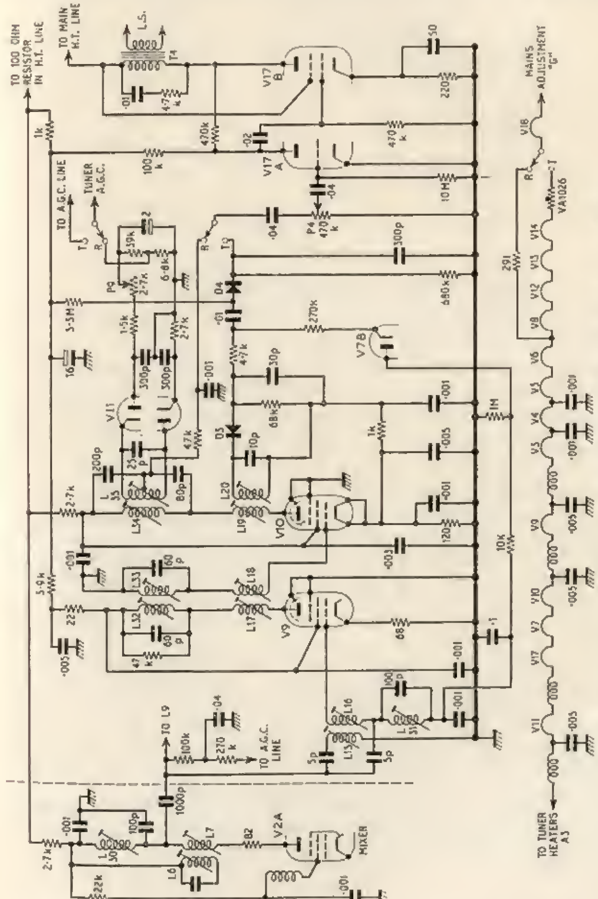


FIG. 13.—DUAL CHANNEL SOUND RECEIVER FOR A.M./F.M. RECEPTION.
L16, L17, L18, L19, L20 are tuned to 38·15 Mc/s and L30, L31, L32, L33, L34, L35 to 10·7 Mc/s. D3 is the television sound detector, V11 the F.M. ratio detector.

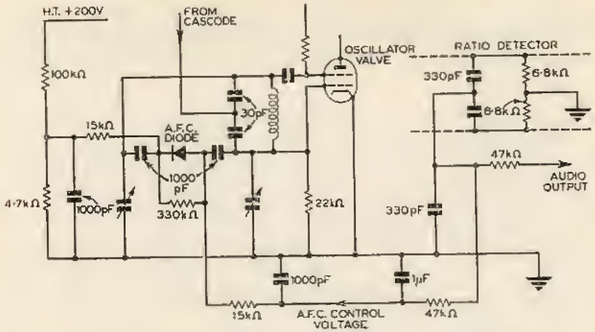


Fig. 14.—Use of a Point Contact or Junction Germanium Diode to provide Automatic Frequency Control on F.M.

This is based on changes of capacitance of the diode with changes of reverse voltage applied across it.

However, it is difficult with such arrangements to ensure the high order of A.M. rejection needed to overcome the "tissue-paper" distortion caused by multi-path ("ghost") interference in some localities. This is mainly due to lack of gain, arising from the high I.F. (usually 38·15 Mc/s). Adjacent-channel selectivity may also be deficient.

In some models an extra I.F. stage is switched into operation on F.M., while others use an intermediate frequency of 10·7 Mc/s on F.M. by means of dual-channel I.F. strips, similar in principle to those used on combined A.M./F.M. sound receivers. Another system is to use dual-conversion with a second I.F. of the order of 6 Mc/s. In a number of models a completely separate F.M. unit, up to and including the ratio detector, is fitted.

Fig. 13 shows a representative sound channel using dual-channel I.F. stages. The anode circuit of the mixer contains circuits tuned to 10·7 Mc/s and 38·15 Mc/s, and both channels are amplified by V9 and V10. The 10·7-Mc/s circuits offer negligible impedance at 38·15 Mc/s, and vice versa. D3 is a conventional sound detector, while V11 is a ratio detector for the F.M. signals. The pre-set resistor P9 is adjusted to provide minimum output of A.M. signals. The two-stage A.F. amplifier (V17A, B) is common to both channels. On F.M. reception the heater supplies to the picture tube and the time-base valves are switched off.

TIME BASE CIRCUITS

50-c/s frame and 10·125-kc/s line time-bases are needed to produce the cathode-ray tube raster. Most time-base circuits

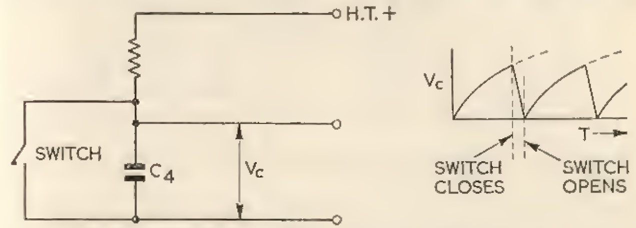


Fig. 15.—Basic Principle of the Saw-tooth Generator.

involve the slow charge and rapid discharge of a condenser. In some cases this is reversed. Fig. 15 shows a condenser charged through a resistor with a discharge "switch" device across C_4. The switch can be a gas-discharge valve (thyratron), but the blocking oscillator is more usual. It operates as follows (Fig. 16): the valve is conducting, any small variation at the grid will be amplified and fed back to the grid. The result is cumulative, and violent oscillation results. On the positive half-cycles grid current flows, producing such a large negative bias across C_5 that the valve is cut off. The negative charge on C_5 leaks through R_{13} until conduction again takes place. The build-up is rapid, and the valve continues to oscillate for a short period and is cut off for a longer period. During oscillation the valve draws a current, mostly from C_4, which charges through R_{12} during the period of cut-off. The oscillation frequency of the valve is incidental: the fact that it discharges C_4 is important, as also is the interruption frequency, which is controlled mainly by the (adjustable) time constant C_5R_{13}. The latter is the "hold" control. Positive-going synchronising pulses, fed to the grid, kick off the oscillation at the right instant to keep the received picture in step with that transmitted.

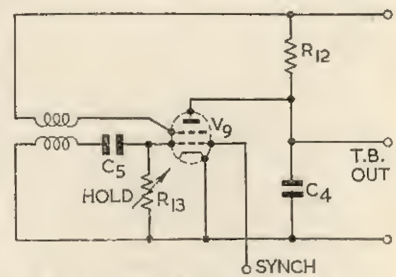


Fig. 16.—Time-base Generator Using a Blocking Oscillator.

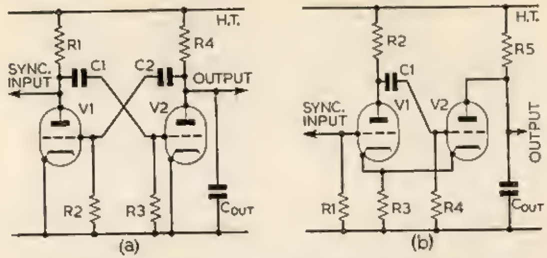


FIG. 17.—BASIC MULTI-VIBRATOR CIRCUITS. (*a*) ANODE-TO-GRID COUPLED, (*b*) CATHODE COUPLED.

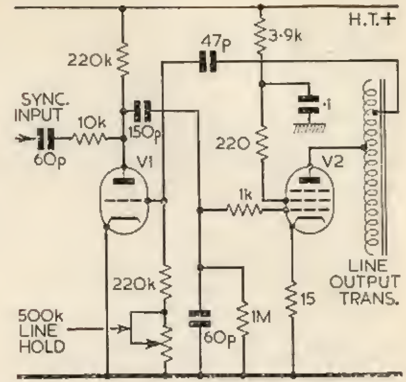
An alternative, popular time-base oscillator is the multi-vibrator, of which there are two basic varieties, the anode-to-grid (see Fig. 17 (*a*)) and the cathode coupled (see Fig. 17 (*b*)) versions.

The action of the anode-to-grid coupled multi-vibrator is as follows: Assume that, at the start, V1 is cut-off, V2 is passing current and C2 is charged. The anode voltage across R4 falls until it reaches a point where C2 discharges through R2, so driving the grid of V1 sufficiently positive for V1 to conduct. When this happens, the voltage across R1 decreases. The voltage on the grid of V2 also decreases, until V2 is cut-off. The position is then reversed, C1 discharging through R3 and the grid of V2 becoming positive so that V2 again passes current. This process continues. Whilst V2 is cut-off, C_{out} charges through R4; when V2 is conducting, however, C_{out} discharges, so that a saw-tooth waveform is produced. As shown, the sync. input is fed to the anode of V1. It is also possible, however, to arrange for the sync. input to be fed to the grid of V1. Control over the oscillator speed is effected by making R3 variable.

The cathode-coupled multi-vibrator circuit operates in the following manner: Assume that, at the start, V2 is cut-off, V1 is conducting and C1 charging through R2. In this condition, C_{out} will be charging through R5, and the negative charge on the grid of V2 will be leaking away through R4. When the grid of V2 is sufficiently positive, the valve will begin to conduct and there will be a drop in the voltage across the common-cathode resistor R3. This voltage drop will lead to a rise in voltage across R2, with a corresponding drop in the current. Whilst V2 is in this way cut-off, C1 discharges, driving the grid of V2 more positive so that V2 is conducting sufficiently for C_{out} to discharge. As the positive charge on the grid of V1 leaks away through R1, V1 will again start to conduct, C1 will charge through R2, and the voltage drop across R3 will again lead to V2 being cut-off whilst C_{out} charges through R5. Control over the hold is effected by making R4 variable. The circuit is easily triggered by feeding the sync. pulse to the grid of V1. In practice, a number of

FIG. 18.—A COMMON VARIANT OF THE MULTI-VIBRATOR IN A LINE TIME-BASE.

The feedback to V1 is via the 47pF condenser connected to a tapping on the line output transformer.



variants of these basic circuits are often to be found. In a number of sets, the screen-cathode section of the output valve forms one section of the multi-vibrator. A more common arrangement, in which the line output stage forms, in effect, part of a multi-vibrator circuit is shown in Fig. 18. In several current models a combination of these two systems is used in the line time-base, the screen-cathode section of the output valve forming one section of the multi-vibrator during the warming up period before the efficiency diode is brought into action, the mode of operation then changing, the main feedback being via a condenser connected to a tapping on the line output transformer. If the anode resistor of one half of a multi-vibrator is connected in the screen circuit, this enables the output to be taken from the anode circuit, and, since the output load is then coupled to the oscillator only via the electron stream of the valve, variations in the output load will have much less effect on the frequency of oscillation. This arrangement is also used in a number of models.

In line output stages it has also been common to use the screen and grid of the output valve in a blocking oscillator arrangement. A separate transformer, or a section of or overwinding on the line output transformer, may be used.

The saw-tooth voltage is transformed to a saw-tooth current for the deflection coils by feeding them from a pentode whose high anode-slope resistance swamps the deflector-coil inductance. The frame output may be fed directly, but the line coils are always transformer-coupled, as the deflection is larger and the available time shorter. The E.M.F. induced across the coils also leads to insulation difficulties, so a step-down transformer of ratio between 4 and 12 to 1 is used to feed them at low voltage and high current (up to 1 A peak). Large voltages still appear at the primary, and the line-output valve has to withstand them without flashover.

Fig. 19.—Effect of "Ringing" on Time-base Waveform.

A difficulty is "ringing" (self-oscillation) between the inductance and stray capacitance of the circuit, resulting in the waveform shown in Fig. 19. A shunt resistor will damp the oscillations, but as it is also present during the forward stroke, the efficiency of the circuit is reduced. A typical circuit is shown in Fig. 20. V10 is the line-output valve, and V11 is the damping or "efficiency" diode. It absorbs no power on the forward stroke, but provides a voltage of about 150 V across C_6, which is added to the H.T. for V10 and for the first anode of the cathode-ray tube (and often also for the frame time-base output).

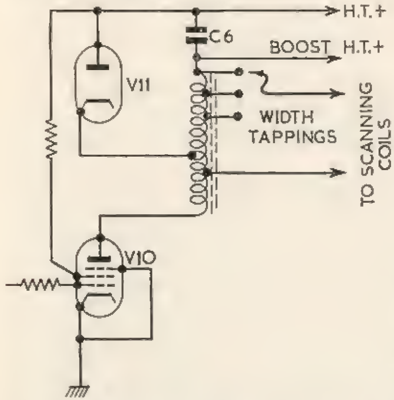


Fig. 20.—Line Time-base Output Stage showing the Efficiency Diode V11.

The waveform produced is not a linear saw-tooth, since the voltage appearing across a condenser charged through a resistor is exponential. If the condenser is charged through a pentode, a constant current flows and linearity results.

It is now common practice to operate the line output pentode "below the knee" of the I_a/V_a characteristic, in which condition the grid potential has little effect upon anode current. The main advantages of this mode of operation are that the E.H.T. regulation is improved, and the fall off in scan power during the life of the output valve is reduced. For example, a drop of 25 per cent in the peak anode current of the valve need result in a loss of scan power of only about 0·25 per cent. This greater consistency of output has made it possible to dispense with the conventional forms of width control.

Tuned Leakage Inductance Transformers

If the leakage inductance between the primary and the E.H.T. overwind of a line transformer is made to resonate, with the effective capacitance across it, to a frequency about 2·7 times that of the effective primary inductance and capacitance, then the peak voltages on the anode of the line output valve and cathode of the boost diode valve are reduced by about 20 per cent, while the voltage on the E.H.T. rectifier anode is increased. Also, with this 2·7 ratio, the ringing voltage of the leakage inductance is zero at the end of the flyback period and does not continue during the scan. This means that there are no striations on the raster due to leakage inductance between the primary and E.H.T. overwind. This system is commonly used for wide-angle tubes.

De-saturated Transformers

Since about 1955, some line output trasnformers have had de-saturated cores, which is to say that the magnetising flux arising from the direct current flowing in the windings is cancelled out. The transformer winding is split at the cathode-tap of the efficiency diode and a coupling capacitor inserted. It will be seen from Fig. 21 (*a*) that the anode current for the line output valve passes through both sections of the transformer but in an opposite sense, so that the D.C. component is largely neutralised. In this arrangement the H.T. feed is through a large choke which may be made variable to form a width control. The system provides greater efficiency for a given core section and is also useful in reducing the 10-kc/s line whistle.

A modification of this system has now been introduced in which the feed choke is not required, being replaced by the line-deflection coils and the associated shorted-turn sleeve. In practice, component values may differ from those shown in Fig. 21 (*b*), derived from a Mullard design.

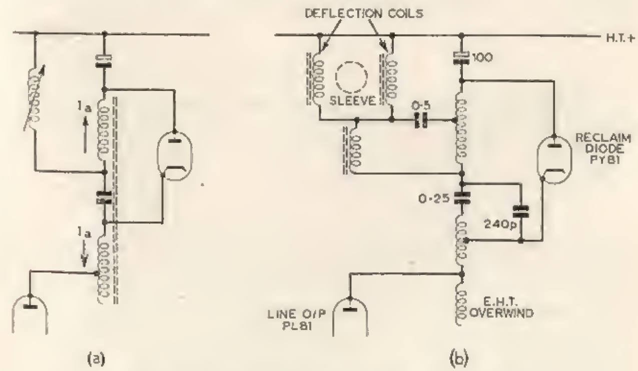


Fig. 21.—De-saturated Line-output Transformers.

(*a*) The basic system. (*b*) A modified system with tuned leakage inductance and linearity sleeve.

Shorted-turn Linearity and Width Controls

Owing to the varying impedance of components in the line time-base during the scanning cycle, an uncorrected time-base would cause the picture to be stretched on the left and cramped on the right. The usual remedy is to connect a saturated reactor in series with the line-scanning coils; this can be arranged to compensate for the impedance variations so that a relatively undistorted picture is obtained. Linearity controls of this type are found on many modern receivers. A disadvantage of this system, however, arises from the tendency of the reactor to induce "ringing", which appears as vertical striations on the left-hand side of the raster, and it also consumes some of the scan power. Ringing can be reduced by damping the saturated reactor by means of paralleled resistors, but this reduces the efficiency of the control and increases cost.

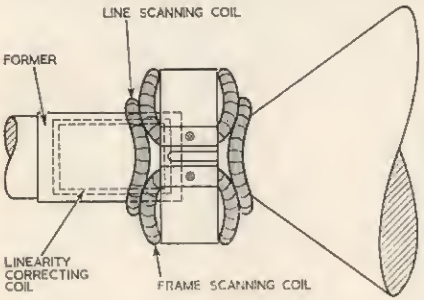
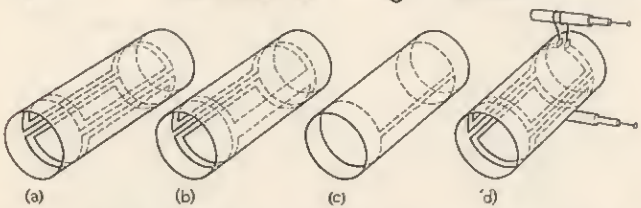


FIG. 22 (*left*).—LINEARITY SLEEVE IN POSITION AROUND NECK OF PICTURE TUBE.

FIG. 23 (*below*).—VARIOUS FORMS TAKEN BY SLEEVE SHOWING FOIL LOOPS INSIDE NON-CONDUCTIVE FORMER.



Now widely used is a linearity control which does not introduce ringing. It consists basically of two rectangular loops of metal foil fixed to a cylindrical former and placed around the neck of the picture tube beneath the line-scan coils. There is no direct electrical connection between the loops and the scanning coils, but a current is induced in the loops by the magnetic field, and this in turn affects the current in the scanning coils. By adjustment of the physical position of the loops the linearity of the line time-base may be controlled. There are several possible versions of this form of linearity control, see Fig. 23.

The adjustment of the loops is critical, and may be made more difficult by the effect of other assemblies on the neck of the tube. For this reason the sleeve carrying the linearity control loops may be cemented to the scanning-coil assembly, and in such cases it is advisable not to disturb the adjustment when changing tubes.

In recent models this sleeve technique has been extended to act as both linearity and width control. This is possible because modern line output stages are designed to provide a nearly constant output throughout the life of the valve. By dispensing with the pre-set width control it is possible to conserve scan power.

Where the shorted-turn sleeve is used for width and linearity adjustments, the usual method of setting, using Test Card C, is as follows:

Picture shape. Adjust the sleeve to provide symmetry of the horizontal and vertical lines and corners by *rotating* the sleeve about the neck. This adjustment is for minimum coupling to the frame coils which would cause poor interlace and geometric distortion.

Width and Linearity. Slide the sleeve *along the neck* without rotating it until the correct width is obtained. With 110° tube masks this may require some horizontal overscan. Correct width setting should also provide good linearity. It should be noted that a sleeve inserted too far into the deflection-coil assembly may cause overheating of the deflection coils.

On tubes having an ion trap, the ion-trap magnet should be checked after any adjustment of the sleeve.

Width control by means of a tapped line output transformer is also now common, as this method also eliminates the saturable reactor type of control.

Synchronising-signal Separation

While the whole television signal is fed through the early stages of the receiver, the synchronising signals must be removed to be fed to the time-base circuits, either before or (normally) after the detector stage. In the British system the synchronising pulses occupy 0–30 per cent modulation and the picture 30–100 per cent, so that an amplitude filter can be used. This may consist of a diode biased to the amplitude of the synchronising pulses so that it will conduct only when the picture is present. The output will therefore consist only of the synchronising pulses.

Alternatively, a pentode may be used with an anode voltage of about 10 V and screen of about 50 V, Fig. 24, which gives the characteristic shown in Fig. 25. Current models for many years have used pentode synchronising-pulse separators because of the amplification possible.

The line synchronising pulses must also be separated from the frame pulses, and, as they are of the same amplitude, a time or

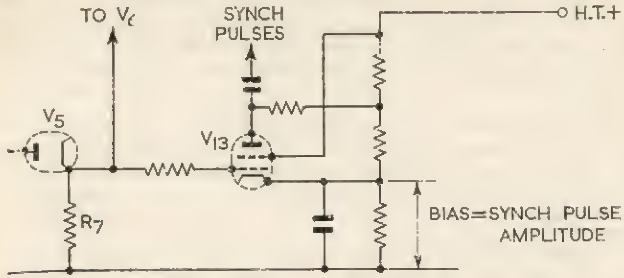


FIG. 24.—SYNCHRONISING SEPARATOR USING SATURATED VALVE.

length filter must be used. A usual method is to apply the pulses to two filters, known as differentiating and integrating circuits.

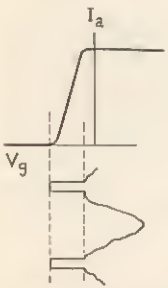


FIG. 25.—OPERATING CONDITIONS OF V13.

In Fig. 26 the time constant C_{10}, R_{15} is short compared with the length of the line-synchronising pulses (about 2·5 μS, *e.g.*, $C_{10} = 50$ pF and $R_{15} = 50$ k). The output voltage (across R_{15}) rises sharply to approximately the full value, but, as C_{10} charges rapidly, the voltage across R_{15} falls to give the waveform shown. For the integrating circuit (Fig. 26) the time constant is long compared with a line-synchronising period (about 50 μS) and, consequently, the voltage appearing across C_{11} is small for line pulses, but when the eight broad 40-μS frame pulses arrive, the voltage across C_{11} builds up. The two states (at the end of even and odd frames) are shown. This appears to produce a flat-fronted pulse, but when the scale is considered, the eight broad pulses total about 400 μS and the rest of the frame period 19,600 μS, a ratio of nearly 1 : 50, so that the pulse may be steep enough to ensure good interlace. Further shaping, however, may be applied.

To reduce the effect of residual line pulses on frame synchronisation, a series-connected clipper diode is frequently incorporated in the frame-synchronising circuit. This gives a short charging and slow discharging time constant to the frame-synchronising separation circuit. Alternatively, a diode to earth may be added and biased so as to conduct during the line pulse period,

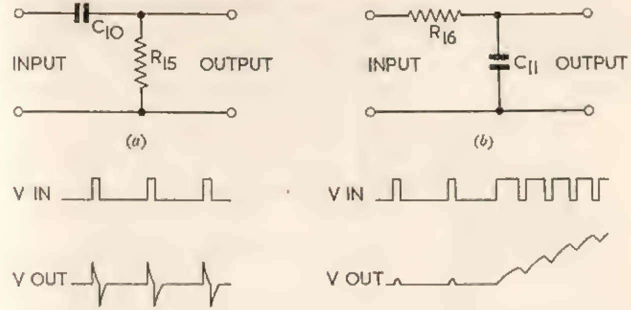


FIG. 26.—WAVEFORMS PRODUCED BY:
(*a*) DIFFERENTIATING CIRCUIT, AND
(*b*) INTEGRATING CIRCUIT.

thereby removing residual line pulses from the train of pulses fed to the frame generator.

Interference to the picture (faint white lines, slightly tilted, across the picture) is sometimes caused by the frame flyback, and suppression, in the form of a voltage applied to one of the picture-tube electrodes, is often incorporated to cut off the scanning beam during the frame flyback period.

Power Supplies

The H.T. is derived by half-wave rectification from the mains, and so is limited to about 180 V. Special valves have been developed to operate with this rather low H.T. voltage, but the line and frame time-base outputs and the cathode-ray tube first anode operate more satisfactorily on about 300 V. The extra voltage can be derived from the line time-base output as described above (under " Time-base circuits "), and is known as the " boost " voltage.

An increase in the efficiency of the H.T. rectification, and hence a somewhat higher H.T. line, is possible by the use of silicon rectifiers. The voltage drop across these rectifiers is much smaller than that across metal (selenium) or valve rectifiers, and does not increase with age.

The E.H.T. may be derived by at least three methods : (i) from the line flyback; (2) by rectifying the output from a separate oscillator operating at about 40 kc/s; and (3) by the " ringing choke " method. In (1), see Fig. 27, V10 is the line-output valve, V11 the efficiency or boost diode, already dealt with, V14 is the high-voltage rectifier, whose heater is fed from an auxiliary

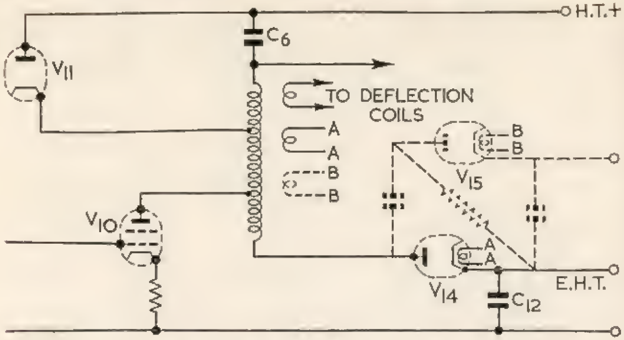


FIG. 27.—LINE FLYBACK E.H.T. CIRCUIT.

winding on the transformer, and C_{12} the reservoir condenser (500–1000 pF). The dotted connections and components show a voltage-doubling circuit though these are seldom used.

In practice, all modern direct-viewing receivers use the line flyback method of E.H.T. generation, developing voltages up to about 16 kV without voltage doubling by means of an E.H.T. overwind on the line output transformer. Some models incorporate E.H.T. regulation using either a non-linear resistive element, such as the "Metrosil", which acts as an "overflow" to prevent the voltage rising above a specified value (means of adjusting this component is sometimes provided), or alternatively, may use one of the more elaborate feedback control systems, in which a small proportion of the output is rectified and used to control the bias on the output stage.

Because of the high frequency of line flyback E.H.T. systems, only a small value smoothing condenser is required: this is usually obtained by coating part of the inner and outer surface of the picture tube with a conductive material (Aquadag).

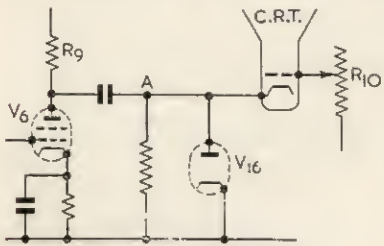


FIG. 28.—D.C. RESTORATION.

D.C. Restoration

The picture signal as transmitted is a D.C. signal in that all its variations start from a datum and are on one side of it, see Fig. 29 (*a*). When such a fluctuating D.C. signal is applied to interstage couplings (*e.g.*, in the video amplifier), only the A.C. part can be passed on, with equal areas

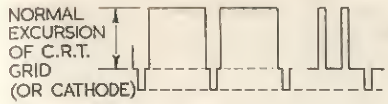
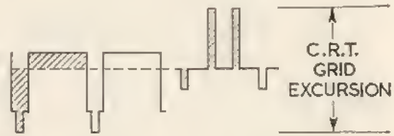


FIG. 29 (*a*).—PICTURE SIGNAL AS TRANSMITTED.

FIG. 29 (*b*).—EFFECT OF INTERSTAGE COUPLING.



of excursion on each side of a datum, Fig. 29 (*b*). This means, as shown, that for driving the cathode-ray tube a much greater total swing must be accommodated. To improve matters the D.C. condition can be restored as shown in Fig. 28, in which the diode will conduct as soon as the point A goes positive, thus ensuring that no part of the signal appears above the datum. The polarity here dealt with is negative in accordance with the output from V6 above. In modern sets, either direct coupling is used or alternatively the D.C. is not fully restored.

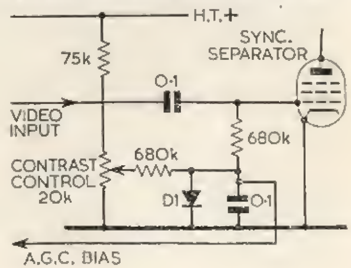
AUTOMATIC PICTURE CONTROL

All but a very few Band I/III receivers incorporate some form of vision automatic gain control (A.P.C.). The different Band I and Band III signal strengths likely to be encountered make this feature desirable if changing from a Band I channel to a Band III channel is to be made free of considerable readjustment of the sensitivity and contrast controls. An alternative approach to this problem, used in several models, is the use of independent, pre-set sensitivity (R.F. gain) controls for each Band.

Mean Level A.G.C.

The simplest, and one of the most common, forms of A.P.C. is to sample the waveform appearing in the grid circuit of the

FIG. 30.—MEAN LEVEL A.G.C. SYSTEM SAMPLING SIGNAL AT GRID OF SYNC. SEPARATOR. D1 IS A DELAY DIODE.



synchronising separator stage. This signal is D.C. restored by the grid current of the synchronising separators. The control voltage derived from this source is then fed back, as bias, to the R.F. and, sometimes, one or more of the I.F. stages. The contrast control then takes the form of a potentiometer determining the level at which the A.G.C. begins to operate. With such a system, it is common, as shown in Fig. 30, to include a clamp diode to delay the effect of the control voltage so that the gain of the receiver strip is not reduced below the required amplification level and to prevent the A.G.C. line going positive when the contrast control is operated. It is also common to include a diode to provide additional delay to the voltage applied to the R.F. amplifier stage, in order to retain maximum R.F. amplification and thereby obtain the best noise factor. The suppressor grid of a suitable valve, *e.g.*, synchronising separator or I.F. amplifier, is often used as a delay diode.

Gated A.G.C.

The system so far mentioned is based on the mean signal level. A disadvantage of this system is that the A.G.C. voltage varies with changes in the picture content as well as with changes in the signal strength. Since, however, it is comparatively rare for the picture content to vary widely—*i.e.*, as would happen if an all-black picture followed immediately after an all-white one—this disadvantage is not so great as it might appear. Further disadvantages are the low gain and long time constant (necessary to prevent re-modulation of the sound or vision) of the circuit. The long time constant means that the circuit will not respond to quick, small variations in signal strength such as those caused by passing aircraft.

To overcome the disadvantage of changes with picture content, especially in receivers intended for fringe-area reception, where considerable picture fading may be experienced, a " gated " system is often used. A number of different arrangements have been employed. In gated systems the amplitude of the signal is measured at some time during the picture waveform when it is at a known level, the receiver gain then being controlled accordingly. In the British television system the black level (representing 30 per cent modulation) is kept constant at the transmitter and is radiated for a few micro-seconds following the line synchronising pulse and for a few lines following the frame pulses. By basing the control bias voltage on these periods, the receiver gain, with A.G.C. applied, can be kept independent of the picture content.

It is more common to sample the signal during the " back porch " period following the line-synchronising pulses than to sample the strength of the carrier at the frame frequency, and an arrangement for sampling at line frequency is shown in Fig. 31. A negative-going waveform is provided by the cathode-follower (video output). This is coupled to the anode of a

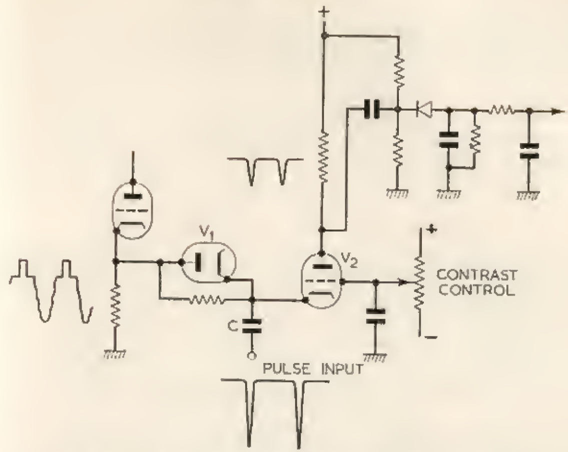


FIG. 31.—VISION A.G.C. CIRCUIT WITH DIODE " GATE ".

" gating " diode to whose cathode is fed a train of large, narrow pulses, also negative going. These " gating " pulses are in this system obtained from the line output transformer. They must be narrower than the " back porch " period and must occur at the centre of this period. If the timing is not correct, it is necessary to delay or to advance the pulse train by some suitable means. The pulses must be larger in amplitude than the video waveform. The diode acts as restorer, and the tips of the pulse train are restored to the potential existing at the cathode of the cathode-follower. This potential, if the timing is right, will be the black level. If the signal strength should increase, then the potential of the restored pulse train will fall with respect to earth, and vice versa. The voltage is applied to the cathode of V2. The bias on the grid of V2 is adjusted, by means of the contrast control, so that the tips of the pulses just cause anode current to flow, thus producing a similar train of pulses across the anode load. When the signal strength alters, and the restored pulse train moves its potential with respect to earth, the pulse train in the anode circuit of V2 alters in amplitude accordingly. This information is rectified, by means of the rectifier and smoothing components shown, so producing a D.C. control voltage.

In some models the gated A.G.C. circuit samples the positive-going video waveform at the cathode of the vision demodulator. With this system, a positive-going gating pulse is required. This has been obtained from the anode circuit of a line multivibrator, and by differentiation of the signal at the grid of the

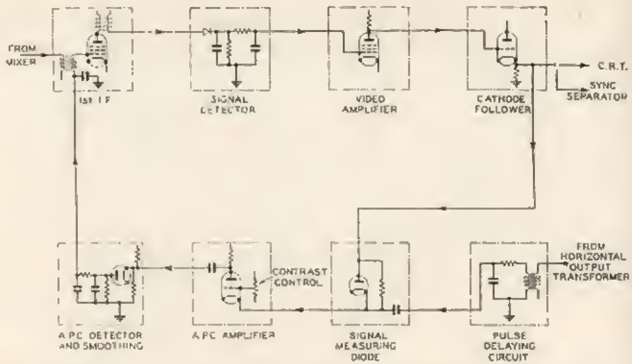


FIG. 32.—SHOWING HOW THE "GATED" ARRANGEMENT IN FIG. 31 IS INCORPORATED IN THE RECEIVER.

synchronising separator. In the latter case the A.G.C circuit has the advantage of being completely independent of the timebases.

" Sync. Cancelled " A.G.C.

A further common alternative A.G.C. arrangement, known as " sync. cancelled " A.G.C., is shown in Fig. 33. The video waveform, with positive-going synchronising pulses and negative-going picture information, is fed to the anode of D1. Negative-going synchronising pulses from the synchronising separator are also fed to the same point. The synchronising pulses are thus cancelled out and, through the D.C. restoration action of the grid

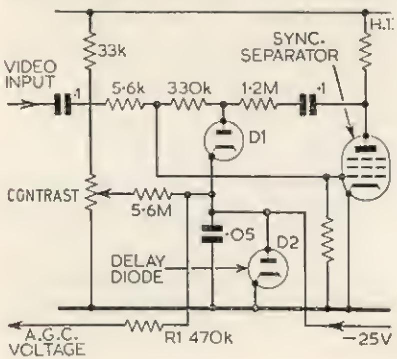


FIG. 33.—COMMON FORM OF "SYNC. CANCELLED" VISION A.G.C.

circuit of the synchronising separator, a waveform the most positive portions of which correspond to black level exists at the anode of D1. D1 is a peak detector, and changes in the black level result in a suitable bias voltage across R1.

A number of variations of these systems have been used. One disadvantage of the arrangements described is that the gain is less than unity. Several circuits have been evolved to provide greater gain, though these have as yet found little application.

FLYWHEEL SYNCHRONISATION

Fringe reception is often rendered more difficult by the line oscillator being triggered by noise pulses reaching the oscillator just before the arrival of the line-synchronising pulse, producing ragged vertical edges to the picture. Several systems have been developed in which the frequency of the line oscillator is not controlled directly by the synchronising pulses but indirectly by means of a discriminator circuit which compares the phase relationship between the line oscillator frequency and the incoming synchronising pulses. Should the frequency of the oscillator begin to " wander " from that of the pulses, the discriminator develops a control potential which modifies the capacitance of the oscillator circuit in such a way as to bring the frequency of the oscillator back into step with the synchronising pulses.

A common form of line flywheel synchronisation circuit is shown in Fig. 34. From this it can be seen that the synchronising pulses are fed, through a phase-splitter transformer, T1, to the phase discriminator circuit, D1 and D2. A saw-tooth waveform, from the line output transformer, is also fed to the discriminator circuit. The integrated output is applied as a bias voltage to control the frequency of the oscillator. In some receivers a valve phase splitter replaces T1. A double diode, such as the EB91, may also be used in place of D1 and D2.

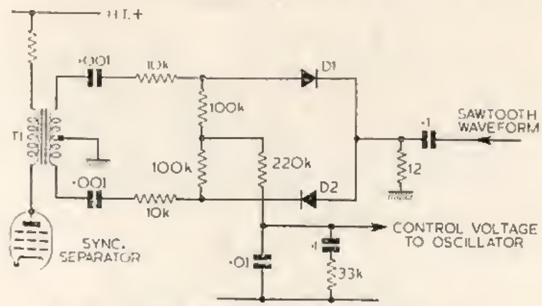


FIG. 34.—COMMON FLYWHEEL SYNCHRONISATION CIRCUIT. D1 AND D2 FORM A PHASE DISCRIMINATOR CIRCUIT.

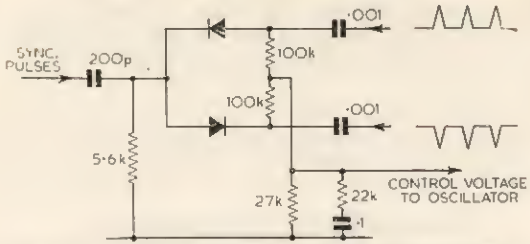


FIG. 35.—ALTERNATIVE FLYWHEEL SYNCHRONISATION CIRCUIT.

An alternative system is shown in Fig. 35. The synchronising input consists of positive-going pulses, which are compared with a series of short pulses of positive and negative polarity derived from the line output transformer during the flyback period. A separate winding on the output transformer provides these pulses.

The two circuits so far mentioned are suitable for controlling a line oscillator of the cathode-coupled multi-vibrator type. Where the line generator is a blocking oscillator, however, the control voltage is applied via a reactance valve. A typical circuit is shown in Fig. 36, the control voltage being derived from a discriminator circuit as shown in Fig. 34.

A system using a different type of discriminator is shown in Fig. 37, and has also been used in a number of models. In this, a pentode, V2, acts as coincidence detector. V1 is biased so as to pass on, amplified, only the negative portions of the differentiated synchronising pulses. These are applied to the screen grid

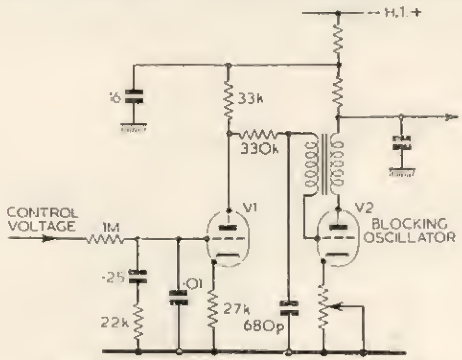


FIG. 36.—REACTANCE VALVE (V1) CONTROLLING A BLOCKING OSCILLATOR (V2).

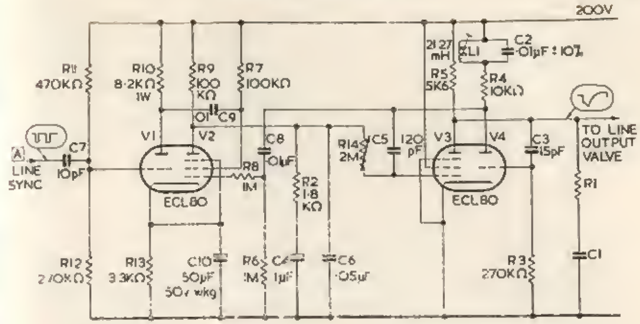


FIG. 37.—FLYWHEEL SYNCHRONISATION CIRCUIT USING A COINCIDENCE DETECTOR (V2).

of V2, a series of pulses corresponding to the line flyback period being fed to the control grid. The mean anode current of V2 varies with the phase difference between these two sets of pulses, a control voltage being developed at the anode to control an oscillator, V3 and V4, of the multi-vibrator variety.

The cycle of operation of this system is

(1) line-oscillator frequency falls;
(2) line-scanning time increases;
(3) line-flyback pulse is delayed;

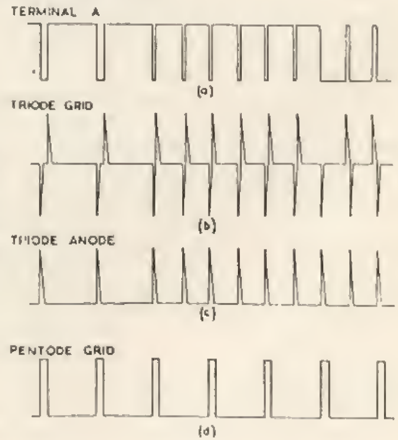


FIG. 38.—WAVEFORMS ASSOCIATED WITH THE PENTODE COINCIDENCE DETECTOR FLYWHEEL SYNCHRONISATION CIRCUIT IN FIG. 37.

(*This diagram, and Fig. 37, are reproduced by courtesy of Mullard, Ltd.*)

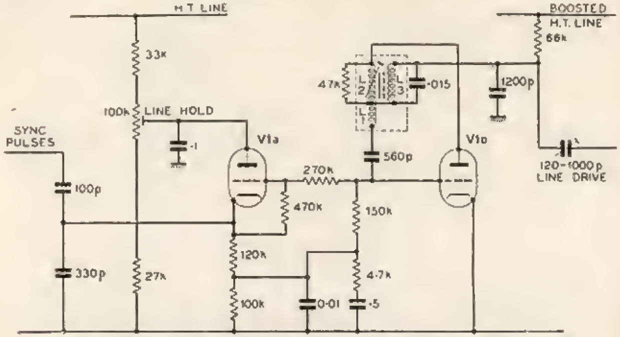


FIG. 39.—FLYWHEEL SYNCHRONISATION CIRCUIT USING A TRIODE COMPARATOR VALVE (V1a).

(4) degree of coincidence between flyback pulse and synchronising detector is reduced;
(5) anode current of coincidence detector falls;
(6) anode voltage of coincidence detector rises;
(7) line-scanning time falls;
(8) line-oscillator frequency rises.

For an initial rise in line-oscillator frequency, the converse of the above stages occurs.

A simpler form of flywheel synchronisation that has recently become popular is shown in Fig. 39. This circuit is generally designed around a single double-triode valve such as the ECC82 or 12AU7. V1b forms a saw-tooth generator, the frequency being roughly determined by L1-L2. The winding L3, contained in the same special can, which in appearance resembles an I.F. transformer, is resonated by the 0·015-μF condenser to the line frequency and is excited into sinusoidal operation by mutual inductive coupling, and this helps to stabilise the oscillator frequency. The sine wave is superimposed on the normal waveform at the grid of the oscillator, and the resulting wave is applied to the grid of V1a, which forms a control or "comparator" valve. This control valve is biased so that only the tips of the sinusoidal peaks are conducted. Simultaneously, to the cathode of this valve is applied the line-synchronising pulses, of negative polarity. The composite pulse, consisting of the peaks of the sinusoidal line-frequency element and the amplified line-synchronising pulses, appears in the cathode circuit. The duration of the composite pulse, and hence the average current passing, depends upon the phase relationship of the two waveforms, and by integrating the current pulses a potential is built up across the 0·01-μF condenser proportional to the duration of the pulses—a longer pulse being passed by V1a when the time-base generator

is running slow compared with the incoming synchronising pulses, and vice versa. This potential is then used to control the speed of V1b by varying its bias. The 100k, 0·01-μF and 4·7k, 0·5-μF components form an "anti-hunting" network by providing a long time-constant in the cathode of V1a. A moderate change of oscillator frequency can also be effected by shifting the cut-off point of V1a by altering its anode voltage, and this fact is made use of to provide a line hold control.

TYPICAL CIRCUITS

In Figs. 40–43 are shown four complete receiver circuit diagrams. These have been selected to show typical circuit practice in the main types of receiver that have been produced—*i.e.*, T.R.F., Band I superheterodyne and Band I/III superheterodyne receivers.

The circuit in Fig. 40 is of a stagger-tuned T.R.F. receiver, with thyratron time-bases and 12-in. picture tube, of the type common up to 1951. Fig. 41 shows a 17-in., five-channel receiver typical of those produced just before the commencement of the I.T.A. transmissions in Band III. Figs. 42 and 43 are recent Band I/III models, the receiver in Fig. 42 (with turrent tuner) being intended for service-area reception and that in Fig. 43 (with incremental switch tuner), incorporating an elaborate, gated A.P.C. system and line-flywheel synchronisation, being intended for fringe reception.

A list of the valve functions in each receiver is given below.

Valve Functions, Circuit Fig. 40

V1 . .	Vision and sound R.F. amplifier
V2, V3, V4 .	Vision R.F. amplifiers
V5 . .	Vision detector and peak amplitude clipper (interference limiter)
V6 . .	Video amplifier
V7 . .	Sync. separator
V8 . .	Frame interlace diode
V9, V10 .	Sound R.F. amplifiers
V11 . .	Audio amplifier (triode), sound detector and interference limiter (follower type) (diodes)
V12 . .	Audio output
V13 . .	E.H.T. rectifier
V14 . .	Line generator (thyratron)
V15 . .	Line output
V16 . .	Frame generator (thyratron)
V17 . .	Frame output
V19 . .	H.T. rectifiers
V20 . .	Picture tube

The controls are as follows: VR1, contrast; VR2, focus; VR3, brilliance; VR4, volume; VR5, line hold; VR6, width; VR7, frame hold; VR8, height; L14, VR9, line linearity.

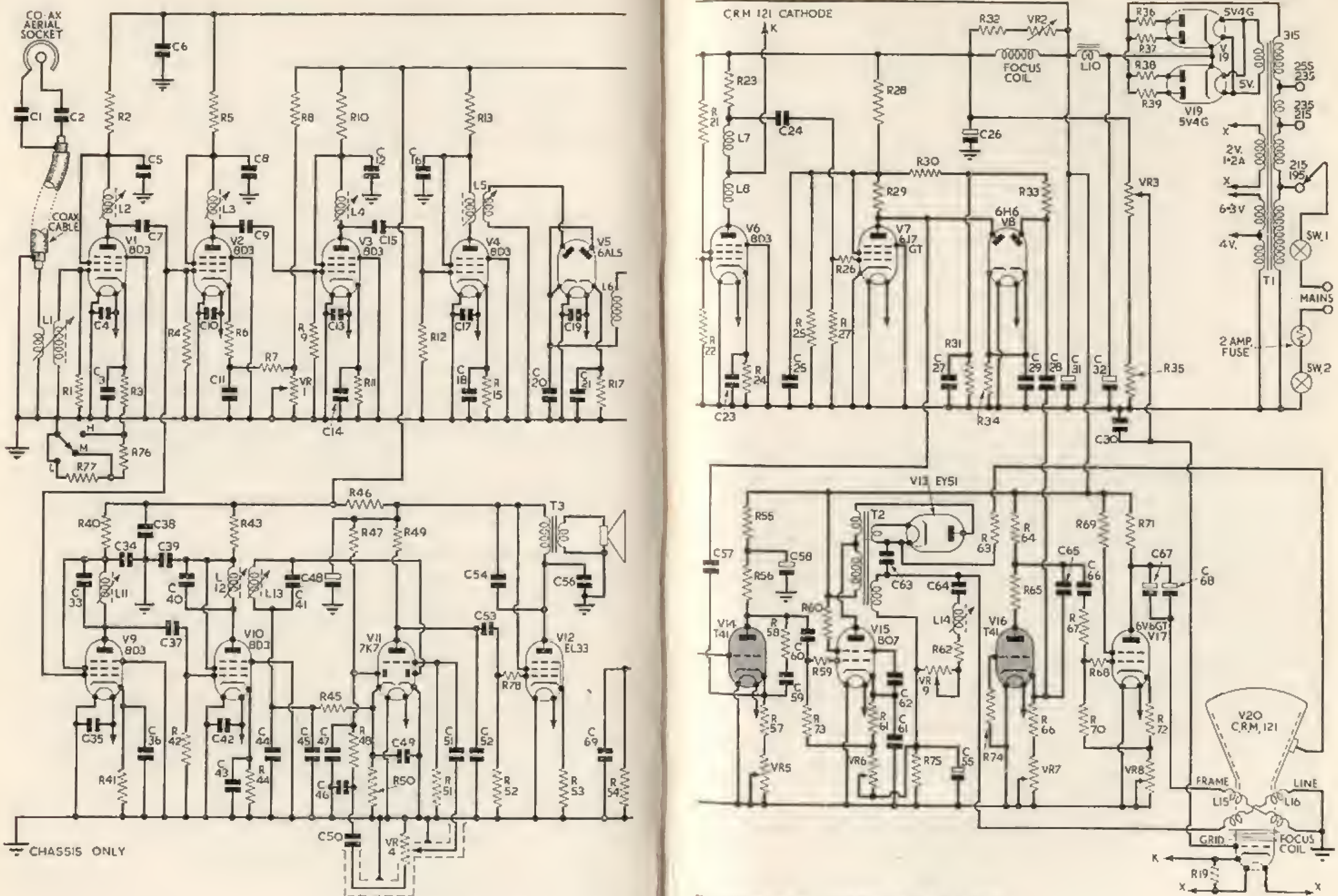


Fig. 40.—Circuit Diagram of a T.R.F. Receiver with Thyratron Time-bases.

Valve Functions, Circuit Fig. 41

V1 . .	R.F. amplifier, sound and vision
V2 . .	Frequency changer (self-oscillating mixer)
V3, V4 . .	Vision I.F. amplifiers. These are followed by a germanium diode detector.
V5 . .	Video amplifier
V6 . .	Sync. separator
V7 . .	Frame interlace (pentode triode-connected) and half line multi-vibrator (triode-output stage forms other section of multi-vibrator)
V8 . .	Line output
V9 . .	Efficiency diode
V10 . .	E.H.T. rectifier
V11 . .	Sound I.F. amplifier
V12 . .	Audio amplifier (pentode), detector and sound A.G.C. (diodes)
V13 . .	Sound and vision interference limiters
V14 . .	Audio output
V15 . .	Frame blocking oscillator (triode) and output (pentode)
V16, V17 .	H.T. rectifiers

The width control in this circuit takes the form of a variable inductor in parallel with a section of the line output transformer. Frame linearity correction is provided for by means of the 25k potentiometer in the feedback loop in the frame time-base. The frame output valve, V17, is resistance-capacitance coupled to the frame deflection coils. E.H.T. is about 6·5 kV, a figure typical of 9 and 12 in. models of this period. The four R.F. vision stages were aligned to the upper sideband in order to improve separation between vision and sound channels. An auto-transformer is arranged to supply some 300 volts r.m.s. to the H.T. rectifiers.

Valve Functions, Circuit Fig. 42

V1 . .	Cascode R.F. amplifier
V2 . .	Frequency changer
V3 . .	Common vision and sound I.F. amplifier
V4 . .	Vision I.F. amplifier
V5 . .	Vision detector (A section) and frame sync. pulse shaper (B section)
V6 . .	Video amplifier
V7 . .	Sync. separator (pentode) and half line multi-vibrator (triode-output stage forms other section of multi-vibrator)
V8 . .	Frame blocking oscillator (triode) and output (pentode)
V9 . .	Sound I.F. amplifier
V10 . .	Audio amplifier (triode) and output (pentode)
V11 . .	Line output
V12 . .	E.H.T. rectifier

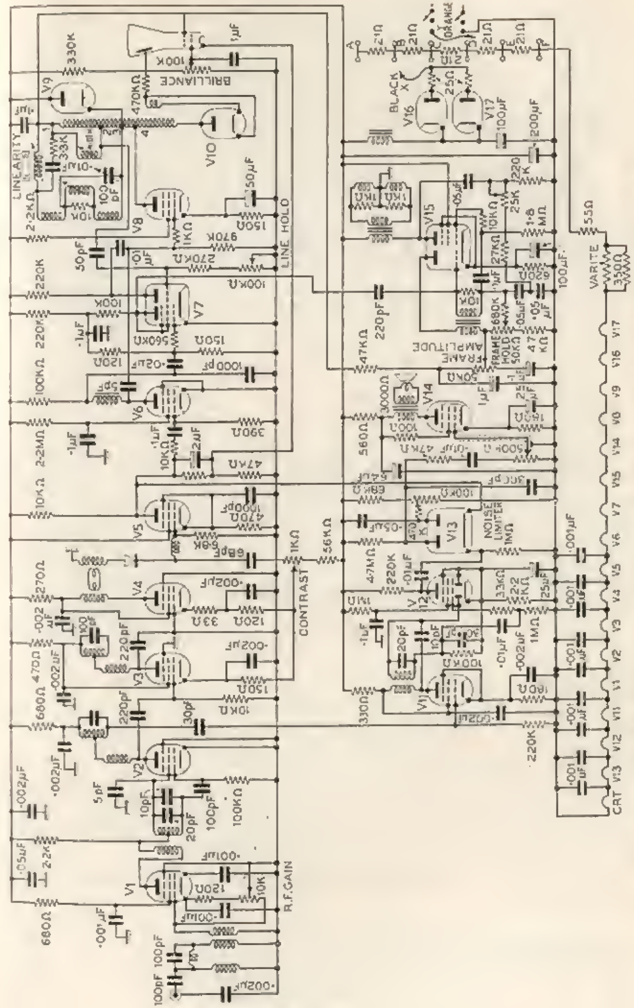


FIG. 41.—CIRCUIT DIAGRAM OF A TYPICAL FIVE-CHANNEL SUPERHETERODYNE RECEIVER.

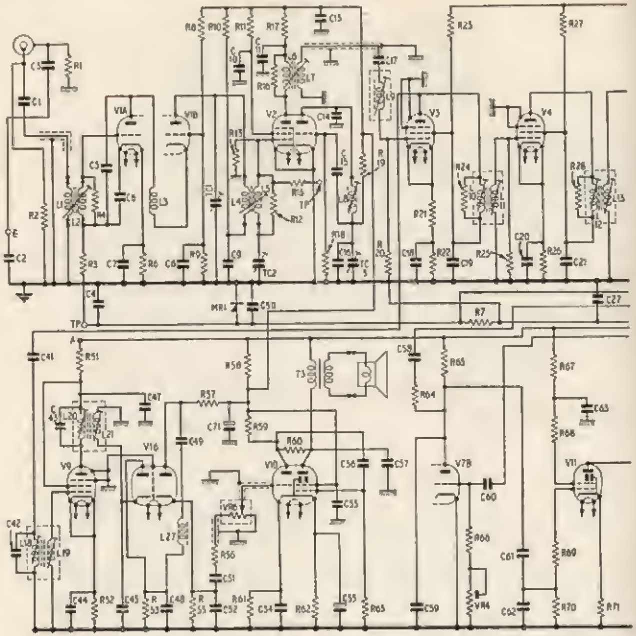


FIG. 42.—CIRCUIT DIAGRAM OF A BAND I/III

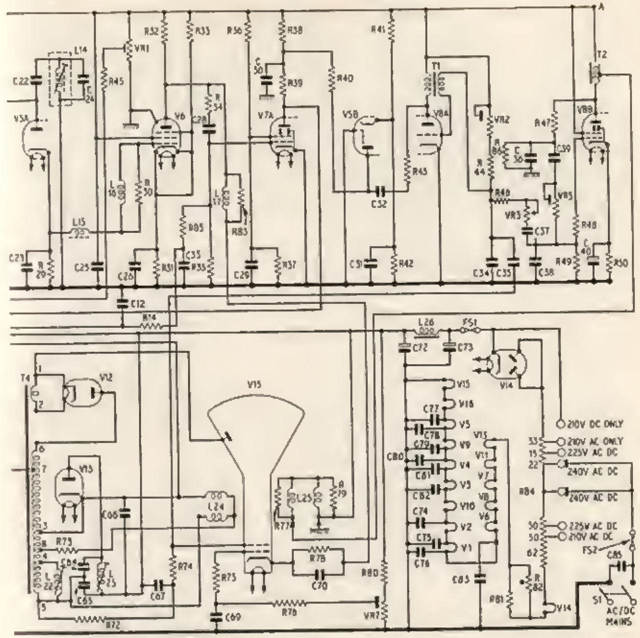
V13	. .	Efficiency diode
V14	. .	H.T. rectifier
V15	. .	Picture tube
V16	. .	Sound detector and interference limiter
MR1	. .	Vision A.G.C. delay diode

The controls are as follows: VR1, contrast; VR2, frame hold; VR3, height; VR4, line hold; VR5, frame linearity; VR6, volume; VR7, brilliance; L22, width; L25, line linearity; TC1, fine tuner.

Frame flyback suppression is applied via C35. Mean level A.P.C. is used.

Valve Functions. Circuit Fig. 43

V1	. .	Cascode R.F. amplifier
V2	. .	Frequency changer
V3, V4, V5	.	Vision I.F. amplifiers
V6	. .	Vision detector



RECEIVER WITH TURRET TUNER.

V7	. .	Video amplifier (pentode) and cathode follower output (triode)
V8	. .	Vision interference limiter (black-spotter type) and A.P.C. amplifier
V9	. .	A.P.C. gate (triode) and sync. separator (pentode)
V10	. .	A.P.C. rectifier
V11	. .	A.P.C. delay diode
V12	. .	H.T. rectifier
V13, V14, V15		Sound I.F. amplifiers
V16	. .	Sound detector
V17	. .	Sound A.G.C. delay diode
V18	. .	Sound interference limiter (follower type)
V19	. .	Audio amplifier (triode) and output (pentode)
V20	. .	Frame interlace diode
V21	. .	Frame multi-vibrator
V22	. .	Frame output
V23	. .	"Flywheel" line sync. phase discriminators

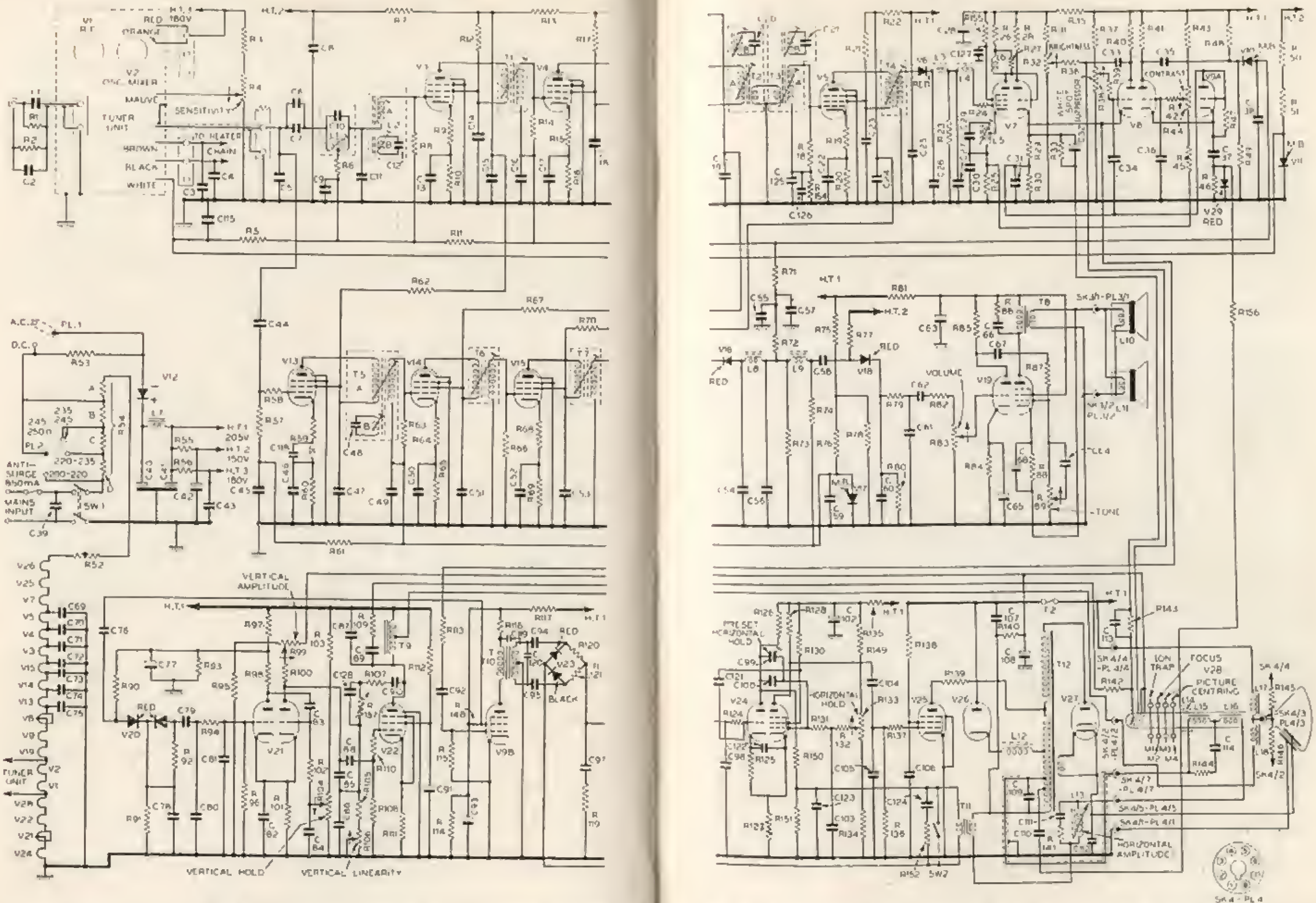


FIG. 43.—CIRCUIT DIAGRAM OF A THIRTEEN-CHANNELED MODEL WITH GATED A.G.C. AND "FLYWHEEL" SYNCHRONISATION.

V24	. .	Line multi-vibrators
V25	. .	Line output
V26	. .	Efficiency diode
V27	. .	E.H.T. rectifier
V28	. .	Picture tube
V29	. .	A.P.C. protection diode

Frame flyback suppression is applied via C89, R109 and R142 to the cathode of the picture tube.

[SECTION 4]

COLOUR TELEVISION

SEVERAL series of experimental colour television transmissions have been radiated, since 1955, by the B.B.C. from its Band I London transmitter at Crystal Palace. These transmissions, which have included live studio productions and films and slides from a colour television studio and control room at Alexandra Palace, usually take place after the close of the normal transmissions and during the afternoons.

These experimental transmissions do not commit the B.B.C. to the adoption of any particular system of colour television. The decision whether or not to introduce a public service of colour television, the starting date and the system to be adopted rests with the Postmaster-General.

A colour television service was introduced in the United States in 1954, and there have been conflicting views expressed on the results achieved, although more than half of the total number of transmitting stations are equipped for radiating colour transmissions. A U.S. table colour receiver costs about £180 with a comprehensive service charge of about £33 a year. Receiver sales have not been as great as was originally predicted, but nevertheless exceeded 150,000 in the two years following the introduction of 21-in. colour tubes.

It seems most probable that some form of public colour service will eventually be introduced in the U.K., and, since the servicing and maintenance of colour receivers present many new and complicated problems, it is important that television engineers should be aware of the main lines of development in this field.

All practical colour television systems are based on the physiological fact that the sensation produced by most of the colour encountered in real life can be reproduced using only three colours. At the transmitting end the scene is analysed by optical filters in terms of the amount of red, green and blue light present in each picture element. At the receiving end the scene is reproduced by the combinations of separate red, green and blue lights having characteristics corresponding to those of the analysing filters at the transmitting end.

Sequential Systems

Several different colour systems have been developed, and it is by no means certain which will eventually be adopted. For example, the basic sequential system, using rotating colour discs, each comprising, say, six gelatine colour filters and rotating at about 1,500 r.p.m., has been developed from the original Baird

experimental work and is the method commonly used for closed-circuit work. In order to obtain a picture of comparable details and flicker to that of black-and-white television it is necessary to increase the frame-scan and line-scan frequencies by about three times that required for monochrome work. The transmission of picture signals would thus require a very large band-width, which, in practice, would make it necessary for the transmitters to operate in Bands IV and V. Also such transmissions would not be "compatible", which is to say that the colour transmissions would not be reproduced on an existing type of receiver as black-and-white pictures. A sequential system which is compatible, and which is in many ways similar to the N.T.S.C. system discussed below, has been demonstrated in France and has the advantage of considerably simplifying receiver circuitry.

N.T.S.C. Systems

The system which has been used in the B.B.C. tests is based on the American N.T.S.C. (National Television System Committee) system, but is modified to meet the requirements of the British 405-line, positive-modulation standards. The system is fully "compatible". Two signals are transmitted simultaneously, one the luminance signal, which contains the picture brightness information, and the other (transmitted as a sub-carrier) is the chrominance signal, which contains the colour information. By a system of frequency interlacing the colour signal does not interfere with the brightness signal, and allows the band-width of the full transmission to be kept within the normal vision band, thus allowing transmissions in Band I and Band III, etc. The colour information transmitted on the sub-carrier consists of hue (*e.g.*, red, brown, yellow, purple) and its saturation, that is to say the purity of the hue as opposed to its dilution with white light. When these signals are picked up by a black-and-white receiver the luminance signal gives a normal black-and-white picture, the chrominance signal producing no visible effect. On

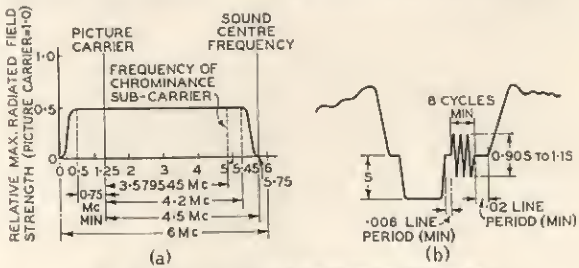


FIG. 1.—N.T.S.C. COLOUR TELEVISION WAVEFORM.
(*a*) Idealised overall transmission curve; (*b*) line-sync. pulse.

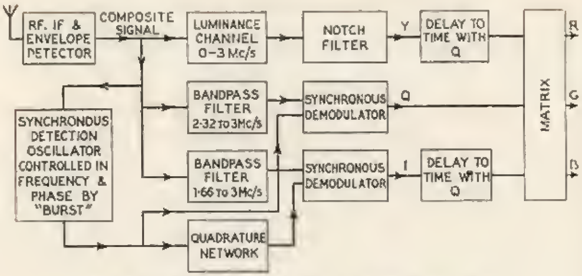


FIG. 2.—BLOCK DIAGRAM FOR A RECEIVER FOR THE N.T.S.C. SYSTEM TRANSMISSIONS.

a colour receiver both signals have their part to play, in order to produce the desired colour. The incoming signal passes in in normal manner through the R.F. and I.F. stages. After the demodulator, however, the signal is fed into the brightness channel, corresponding to the usual video channel, and modulates simultaneously the three grids of a tri-colour cathode-ray tube. The demodulated signal is also passed through a band-pass filter in order to separate the colour information from the brightness signal. Then, by a synchronous detection system in which the

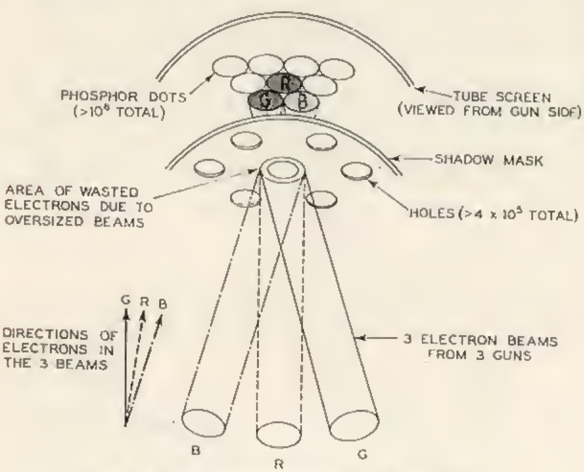


FIG. 3.—SCHEMATIC DIAGRAM OF A THREE-BEAM, SHADOW-MASK COLOUR PICTURE TUBE.

signal is heterodyned with two sine waves having the same frequency and the phase as the component to be extracted, two colour-difference signals are obtained. Subsequently, by means of an adding circuit, a third colour component is derived. The three colour components are then fed to the three cathodes of the tri-colour cathode-ray tube.

There are several methods of locking the receiver synchronous detection reference oscillator in frequency and phase to a reference signal. The crystal and automatic feedback loop is a good example. The reference signal consists of a " burst " of eight cycles of a sine-wave of sub-carrier frequency and phase transmitted in each post line-synchronising suppression period. The amplitude of the " burst " sine-wave is half the magnitude of the synchronising pulses, with the mean value at black level.

In the tri-colour cathode-ray tube three separate beams come from independent cathodes within a three-beam shadow-mask picture tube (developed by R.C.A.). The 21-in. R.C.A. tube contains a screen of 400,000 groups of three colour-fluorescing dots of phosphor. The three dots in each group produce red, green and blue light respectively, and the three electron beams coming from its own gun are so directed through the shadow mask that each beam falls upon only one dot in each group. There are thus effectively a red, a blue and a green gun operating simultaneously, while the patches of light produced by the three beams subtends such a small angle at the observer's eye that each beam is not separately distinguishable.

An alternative system of reproduction is to produce three separate images on three separate projection-type cathode-ray tubes having red, green and blue screens and then to combine the images optically by means of mirrors. An advantage of this system is that it overcomes the high cost of replacement associated with the tri-colour tube.

The development in the United Kingdom of Dr. Gabor's " flat " cathode-ray tube may eventually simplify colour display.

Subjective Colour System

Considerable interest has been shown in a proposed system based on the use of only *two* simple signals carrying colour information, investigated in the United States by Dr. E. H. Land. The system depends for many of its colours upon subjective effects, believed to occur in the brain, whereby the viewer receives the impression of colours which are not actually present in the received picture. " White " may be used as one " colour " component, while a red channel, for example, could be used for the other signal. While a considerable measure of agreement as to the subjective effects has been shown to exist between different observers, it is generally believed that, at the present stage of development, a television system based on pictures using this technique would have a most limited range of chromasticities compared with, for example, the more complex N.T.S.C. system.

Experimental Colour Receiver

A typical experimental British colour television receiver, measuring $21\frac{3}{4} \times 28\frac{1}{2} \times 31\frac{3}{4}$ in., developed by the General Electric Company, uses 35 valves and a 21-in. R.C.A. shadow-mask picture tube.

The receiver power pack incorporates direct rectification of the mains supply to provide one H.T. line of 250 volts at 200 mA, and a second H.T. line of 450 volts and 400 mA is obtained by a voltage-doubling circuit. A stabilized negative line of -150 volts is also available for bias supplies.

The tube E.H.T. supply of 23 kV at 1 mA is obtained directly from the line flyback without voltage doubling, and a triode shunt regulator is used to stabilise the E.H.T. and thereby minimise the effect of E.H.T. changes on the convergence of the three electron beams.

Passive convergence circuits are fed from the line and frame time-bases and supply the appropriate current waveforms to the dynamic convergent coils mounted round the neck of the tube. Direct currents are also applied to these coils for static convergence adjustments, and all the preset convergence controls are easily accessible at the front of the receiver. Line and frame raster shift is controlled by D.C. injection into the scanning coils.

On the signal side a standard R.F. switchable tuner feeds a slightly modified production type I.F. dock. Sound rejection and sound I.F. take-off conform to usual monochrome practice, but in the vision circuits two separate crystal detectors (GEX54's) are used to provide isolation between the luminance and chrominance channels. This arrangement enables a high-definition luminance signal to be maintained, and when this is fed to the ferrite-loaded delay line (to provide time coincidence of luminance and chrominance) small reflections in the line are prevented from disturbing the smooth and symmetrical chrominance-channel frequency response.

The luminance signal is amplified by two video stages in a "boot-strap" circuit and is ultimately fed in the correct drive ratios to the three cathodes of the tube. Master brightness is controlled by a bias arrangement in one of the video stages, and the D.C. component of the signal is maintained to within about 1 db.

Two chrominance amplifiers with a 6-db band-width of ± 500 kc/s supply two "clamping" triodes for high-level demodulation along the red and green difference axes, R–Y and G–Y. After filtering, these difference signals are fed to the red and green grids of the tube, and also to a matrix amplifier which forms the B–Y signal for the blue grid of the tube. A reference frequency amplifier provides the two appropriately phased reference signals for the triode demodulators.

A front-panel chrominance-gain control is provided for adjustment of the colour saturation.

FIG. 4.—TOOL KITS FOR SERVICE ENGINEERS.

This tool wallet (type F) is one of several kits of tools for radio and television service engineers marketed by Philips Electrical Ltd. It contains the following tools: general purpose pliers (insulated); pointed nose pliers (insulated); side cutters (insulated); multi-purpose trimming tool; tweezers; insulated screwdriver handle with three double-ended screwdriver shanks (for slotted and cross-cut screws); offset screwdriver; and voltage tester/grub screwdriver.

The continuous reference signal required for synchronous demodulation is obtained from an L.C. oscillator, which is frequency and phase locked by a two-mode A.P.C. loop, or D.C. quadri-correlator.

One of the two detectors in the A.P.C. loop provides a D.C. voltage only when a burst signal is present and when the oscillator is phase locked. Since this is a synchronous detector, it provides an accurate indication of the presence of a burst even under adverse signal-to-noise conditions, and is used as a colour "killer" control for switching off the chrominance channel automatically when a burst signal is absent. The output of this detector is also fed as an automatic chrominance control or A.C.C. signal to bias the chrominance amplifier from which the burst output is taken.

The colour burst is separated from the chrominance waveform and amplified before being applied to the A.P.C. detectors. The separation is carried out by a gating circuit which switches on the burst amplifier only during the burst period of about 4 microseconds. In order to be quite independent of line time-base synchronisation, the gating circuit operates from the back edge of the line-synchronising pulses appearing in the synchronising separator output.

[SECTION 5]

TRANSISTORISED RECEIVERS

THE first portable transistorised receiver operated from either batteries or mains supplies and using 21 transistors and 12 crystal diodes for all stages except E.H.T. rectification was marketed in the United States by Philco during 1959. An 8-in model was marketed in Japan in 1960. Experimental models, including a Mullard design, have been demonstrated and described (*Journal of the Television Society*, Vol. 8, No. 11, 1958) in the United Kingdom.

The main technical problems involved with transistors are: (1) the V.H.F. front-ends and I.F. strips; (2) the provision of sufficient video frequency output; and (3) line scanning power requirements.

The practical solution of (1) has become possible with the development of transistors such as alloy diffusion and surface barrier types, having good performance characteristics extending well into the V.H.F. range, and it is now possible to design satisfactory vision and sound receivers. The American Philco model has four vision I.F. stages stagger tuned around 45 Mc/s. The Mullard receiver used five stagger-tuned vision I.F. stages on about 19 Mc/s.

Problems (2) and (3) would be simplified by the development of transistors which would withstand high collector potentials. For (2) it is difficult to design a transistor video amplifier providing a peak-to-peak output of the order of 80 volts as required for a conventional picture tube. The Mullard design, which used a standard type of tube, had a " beanstalk " video amplifier with five transistors. An alternative solution is to be found in the development of high-slope picture tubes requiring less video drive.

Scan Magnification

One method of reducing the power requirements for line scanning, adopted in the Mullard design, is the use of a magnetic scan magnification system capable of providing a power saving of about 100 : 1 for the line time-base and about 4 : 1 for the frame time-base. This is based on a magnetic focusing system which magnifies the scan deflection as follows:

If an electron path is through a fixed magnetic field having opposite sense on either side of the cathode-ray-tube axis between the deflection assembly and the screen, then the deflection angle of the beam can be increased in a manner analogous to an optical lens. Normally, however, with such an arrangement the deflec-

tion in a plane at right angles to the plane in which there is magnification will be decreased. However, if the field strength of the magnifying lens is increased beyond a certain point the scan in the second plane is also magnified, though with a reversal of sense. Simply interposing a magnifying lens would, however, increase spot size as well as the deflection angle, so that little benefit would be obtained. This difficulty can be overcome by the use of a quadrupole focusing system, comprising a pair of quadrupole magnet assemblies spaced a short distance apart along the tube neck, and having diverging planes set at 90° relative to each other. Adjustable magnifying lenses have been developed which overcome deflection defocusing by the use of poles shaped as equilateral rectangular hyperbolæ, and which retain a good raster shape. To maintain focus in the horizontal direction when the beam is deflected vertically there are additional correction windings, energised by the frame time-base, on the deflection yoke. It should be noted that the final focus is more sensitive to E.H.T. variations than a conventional system.

The Mullard receiver used a separate stabilised E.H.T. generator based on two OC16 power transistors in a square-wave 400-c/s oscillator circuit and a voltage-doubler rectifier circuit providing some 18 kV stabilised to within $\pm 0{\cdot}3\%$.

Optical Magnification

The American Philco receiver overcomes deflection power problems largely by the use of a 2-in. tube and an optical magnification system which provides a virtual image some 7–8 times that of the real image, to provide a 11-in. × 8½-in. picture. The virtual image appears to be placed several feet behind the set, and a front visor is used to permit viewing in sunshine. The optical system is shown in Fig. 2. The light from the 2-in. tube is projected on to a two-way mirror—termed a " beam splitter " —which reflects the light and yet is transparent to the viewer. This mirror is mounted above the picture tube and directly behind the viewing aperture. The light from the tube is reflected by the two-way mirror on to a spherical mirror. The effect of the spherical mirror is to produce a virtual image appear-

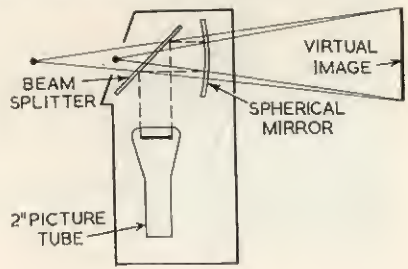


FIG. 1.—OPTICAL MAGNIFICATION SYSTEM USED ON PHILCO TRANSISTORISED RECEIVER.

ing magnified behind the set when viewed through the beam splitter mirror.

In this design the 9-kV E.H.T. is obtained with a voltage-doubler using two thermionic rectifiers from a line flyback system.

Power Supplies

The experimental Mullard receiver operated from a 12-volt silver–zinc rechargeable battery with a total power consumption of 12 watts. The Philco model, which weighs 15 lb., and measures $8\frac{3}{4}$ in. × $5\frac{5}{8}$ in. × $16\frac{5}{8}$ in. high, operates from either A.C. mains or an internal battery which is rechargeable from an internal battery charger. It is claimed that each battery can be recharged 20 times and provides 4 hours service for each charging. The receiver cost is about £89, and the batteries a little under £2. The Japanese "Sony" 8-in.-model, which weighs 13 lb., can also be operated from mains supplies or batteries.

TRANSISTOR D.C. INVERTERS

The operation of conventional television receivers from low-voltage D.C. sources, such as car batteries, has until recently required either some form of rotary conversion machine or a high-wattage vibrator unit. A new form of electronic conversion has become possible with the development of power transistors capable of switching relatively high currents.

In order to achieve D.C. to A.C. conversion, the steady direct current must be "chopped" into a repetitive series of pulses which can subsequently be stepped up to any required voltage by normal transformer action. In a vibrator unit this chopping or switching is done mechanically. In a transistor converter the transistor acts as an electronically controlled "on–off" switch. A junction power transistor can form an almost ideal switch: when the transistor is "off" only the very low collector cut-off current flows; when "on" it behaves as a low resistance. By being made to oscillate, the transistor automatically varies between these two conditions, and can thus be used to interrupt a D.C. source.

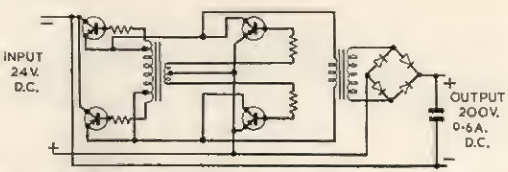


FIG. 2.—TRANSISTOR D.C. CONVERTER SUITABLE FOR OPERATION OF TELEVISION RECEIVERS.

(Valradio Ltd.)

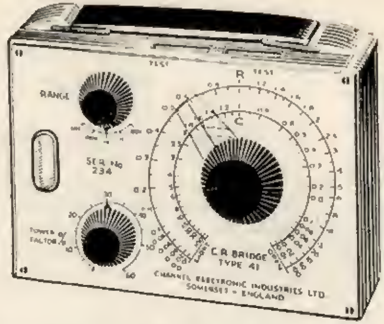


FIG. 3.—TRANSISTORISED SERVICING EQUIPMENT.

Transistors have made possible compact pocket-sized test instruments with negligible battery costs. This $4\frac{1}{2}$ × $3\frac{1}{2}$ × $1\frac{1}{2}$ in. resistance-capacitance bridge, weighs only about 12 oz., and measures capacitances of 5 pF to 20 μF and resistances from 5 ohms to 20 MΩ.

(Channel Electronic Industries, Ltd.)

Although the above action forms the basis of all transistor converters, there are a number of possible circuit arrangements, including the "ringing choke" for low-wattage application, and the push–pull transformer-coupled circuit for medium-power work. For high-wattage requirements, such as the operation of a conventional television receiver, a suitable circuit is the polarity changer arrangement shown in Fig. 3, using four (or a multiple of four) power transistors. The representative unit shown provides a maximum output of the order of 200 volts at 0·6 amp. from a 24-volt D.C. source.

FIG. 4.—VALVE VOLTMETER KIT.

The construction of high performance test instruments by service engineers—at an appreciable saving in cost compared with factory built equipment—has been greatly simplified by the use of printed circuit wiring panels. This Heathkit valve voltmeter, utilising a gold plated, copper-foil printed panel, measures a.c. volts (r.m.s. and peak-to-peak), d.c. volts, resistance (to 1000 megohms) and decibels (zero centre scale). The input impedance is 11 megohms and it has a $4\frac{1}{2}$ in., 200 μA movement. An R.F. probe is available for use up to 100 Mc/s (usable indication to 300 Mc/s).

(Daystrom Ltd.)

[SECTION 6]

PROJECTION TELEVISION

Two distinct methods have been employed for obtaining large-screen television pictures. The first method is by the use of special cathode-ray tubes having the viewing end of the tube in large dimensions, *e.g.*, 24 in. wide, the second method is by employing a small-diameter cathode-ray tube, giving a brilliant picture, which is then reflected from the end of the tube through a suitable optical system on to a large screen. This latter system is known by the designation "large-screen projection television". It can be divided into three main types.

THE BACK PROJECTION SYSTEM for domestic receivers, in which the optical unit is situated behind the screen, the latter being of ground glass or some other suitable translucent material. This method has been used in the Philips, and a number of other manufacturers' large-screen projection sets.

THE FRONT PROJECTION SYSTEM for domestic receivers. In this case the screen is separate from the receiver unit, and an optical system is used to project the enlarged picture on a screen of high reflective power suspended on a wall directly facing the

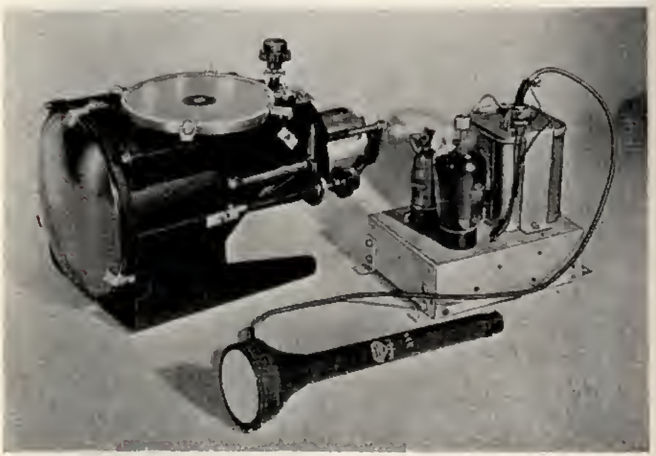
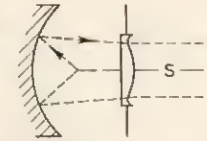


FIG. 1.—COMPONENTS OF THE MULLARD PROJECTION TELEVISION SYSTEM.

FIG. 2.—BASIC PRINCIPLE OF THE SCHMIDT OPTICAL SYSTEM.

The spherical mirror is the main focusing element.



lens of the receiver. This is the system employed in the Decca and Philips large-screen front-projection receivers.

LARGE-SCREEN PROJECTION suitable for cinemas and theatres. This employs the ordinary Schmidt optical system, whereas the systems above employ the Schmidt "folded optical" system using plane reflecting mirrors.

THE SCHMIDT OPTICAL SYSTEMS

It will be appreciated from the above notes that two important items in any system of projection television are the special type of cathode-ray tube employed and the optical projection system.

THE DIRECT SYSTEM. The Schmidt optical system is shown in its simplest form in Fig. 2, in which it will be seen that light from an object in the focal plane of the mirror is reflected back through a correcting plate or lens, the purpose of which is to eliminate spherical aberration.

Fig. 3 shows how this principle can be applied in a television projection unit. From this it will be seen that the high-intensity tube is arranged co-axially with the spherical mirror, the position of the tube along the axis being adjusted during practical tests. The light emitted from the fluorescent screen of the cathode-ray tube is reflected by this mirror, and passes through the correcting plate or lens on to the screen of the television receiver. The hole at the centre of the mirror serves a double purpose. First, if the mirror had no aperture, most of the light falling on the

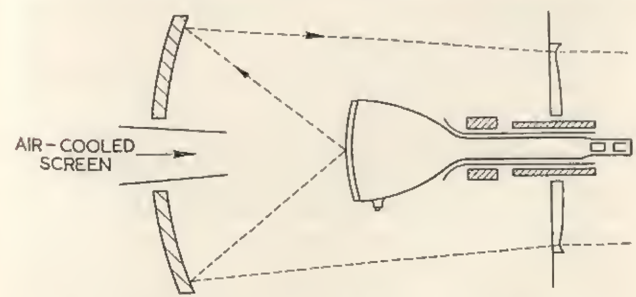


FIG. 3.—SCHMIDT OPTICAL SYSTEM APPLIED TO PROJECTION TELEVISION.

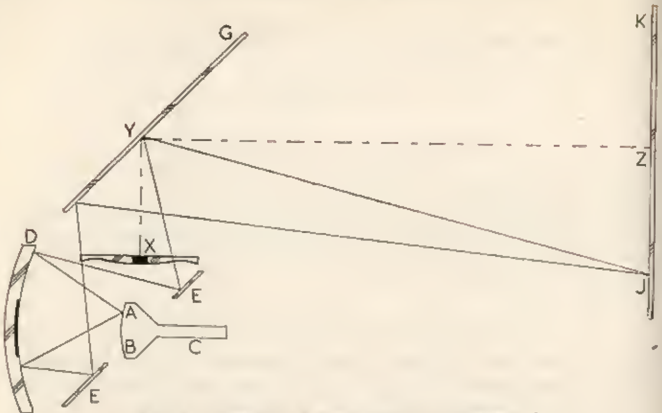


FIG. 4.—SCHMIDT "FOLDED OPTICAL" SYSTEM.

centre portion would be reflected back on to the face of the projection tube, with a consequent blurring of the image. Secondly, the aperture allows for the air cooling of the tube face, should this be found desirable with high-intensity tubes.

THE "FOLDED" SYSTEM. In the "folded" version of the Schmidt optical system, which is shown in Fig. 4, the cathode-ray tube C projects through a central aperture in a mirror E, which is inclined at an angle of 45° to the axis of the spherical reflector. The inclined mirror E catches the light from the spherical reflector and directs it through the correcting lens X on to a second plane mirror G, from which it is again reflected on to the projection screen.

CATHODE-RAY TUBES FOR PROJECTION SYSTEMS

Tubes for Large-screen Projection

The projection tubes used for large-screen television equipment have an anode voltage of 50–80 kV. The average beam current is 1–2 mA with a peak value of 15 mA, the cut-off and drive voltages being respectively minus 500 and plus 400 V. A high-frequency vertical oscillatory motion is imparted to the beam to produce "spot-wobbling", as it has been found that this increases the brightness of the picture and eliminates field line structure. The diameter of the face of the tube is 9 in., and the outer surface of the tube face is cooled by a current of air blown through the centre aperture of the spherical mirror. A magnetic focusing coil is used; the deflection system also employs magnetic coils. An eight-pole magnetic field is used for correcting pin-cushion distortion of the picture.

Tubes for Domestic Projection Receivers

Those receivers employing the folded optical system use a smaller picture tube. The following notes refer to the Mullard type MW6-2, which has a screen diameter of 2½ in., and which is designed to operate at an anode voltage of 25 kV. At a beam current of 100 μA, the spot size is 170 μ (0·0068 in.). The tube is quite conservatively rated and can, if necessary, pass higher peak currents. The spot size is then somewhat increased, with the consequent reduction in picture definition, but, as this current corresponds to peak white, slight loss of definition can be tolerated. The design of the electrode assembly is, of course, governed mainly by the consideration of beam size. The requirements are that the beam must be of such dimensions as to produce a spot of the required diameter, yet not so concentrated that mutual repulsion of the electrons produces blurring of the spot. Further, the beam at its widest diameter must be small enough to keep the electrons well clear of the tube walls and the anode when fully deflected. Finally, the I_a/V_g curve must be sufficiently steep to allow the tube to be driven by a normal video-output valve.

A sectional drawing of the tube is reproduced in Fig. 5. A spark trap, consisting of a ring-shaped electrode, is situated between the grid and the anode, and is connected to one of the base pins, which should, in turn, be connected to chassis. Any discharge which might occur, due, for example, to the release of a small amount of gas as the result of unintentional overload, will take place between the anode and the spark trap, thus avoiding damage to the cathode.

The external surface of the neck and cone is coated with a graphite preparation, and must be earthed. This coating, with the glass envelope and the internal metallising of the tube, forms a capacitance of approximately 450 pF which, with a 1M resistor in the 25 kV lead, serves as the final smoothing for the E.H.T. supply.

The most conspicuous external feature of the tube is the glass shield surrounding the anode terminal. This shield obviates risk of flashover or leakage between the E.H.T. connection and the deflection coils or the graphite coating.

The luminescent screen is backed by a metallic coating.

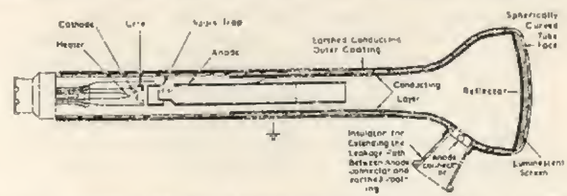


FIG. 5.—SECTIONAL DRAWING OF THE MULLARD MW6-2 CATHODE-RAY TUBE FOR PROJECTION TELEVISION.

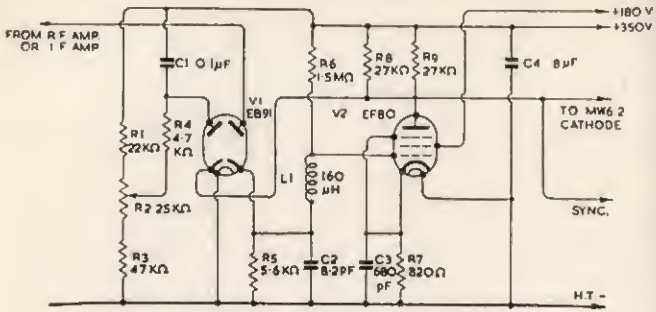


FIG. 6.—VIDEO OUTPUT STAGE USING EF80.

Compensation for Pin-cushion Distortion

An optical system incorporating a spherical mirror introduces a certain degree of pin-cushion distortion, which, in the Mullard projection television system, is compensated in the design of the deflection coils.

CIRCUITRY

When it is intended to incoporate a projection unit in a television receiver, there are several points in the circuit and general design which should be borne in mind.

Video Drive

By using cathode compensation, it is possible to use an EF80 R.F. pentode in projection video stages quite satisfactorily. A suitable circuit is shown in Fig. 6. This circuit has a high-value cathode bias resistor (820 ohms) and a high value of anode load (13,500 ohms). With this load resistance a current swing of only 6·3 mA is required for 85-V output, and this arrangement can be used because of the high feed-back factor provided by the cathode resistor.

The ideal cathode resistance for feed-back purposes is a little too high for bias purposes, and a correcting positive bias (0·9 V) is applied to the grid through resistor R6. The demodulator and interference limiter are also shown in Fig. 6.

The potential drop across the anode load under quiescent conditions is approximately 55 V, and the maximum swing from the H.T. line may therefore be in excess of 155 V. For this reason the anode must be fed from an H.T. line of at least 275–300 V, and preferably 350 V.

The video stage shown in Fig. 6 has a gain of approximately 11·5, so that the last I.F. stage and demodulator must be capable

of delivering at least 10 V peak-to-peak to the video stage.

Video Drive Using PL83

Where it is required to take full advantage of the MW6-2 projection picture tube, a video stage capable of a greater output voltage than that obtainable with EF80 may be desirable. A suitable circuit using PL83 is shown in Fig. 7. An EF80 video stage is in practice seldom used in projection models.

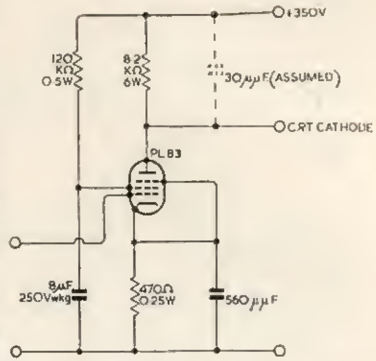


FIG. 7.—VIDEO OUTPUT STAGE USING PL83.

The cut-off limits for the MW6-2 tube are −40 and −90 V. In order to cope with the highest cut-off value, the required peak-to-peak signal, assuming 30 per cent synchronising ratio, will be 129 V. To allow for all tolerances, a nominal output of 150 V has been assumed in the circuit calculation.

Frame Time-base Generator

The frame-deflection coils require approximately 500 mA peak-to-peak for full deflection, and have a resistance of 12·2 ohms.

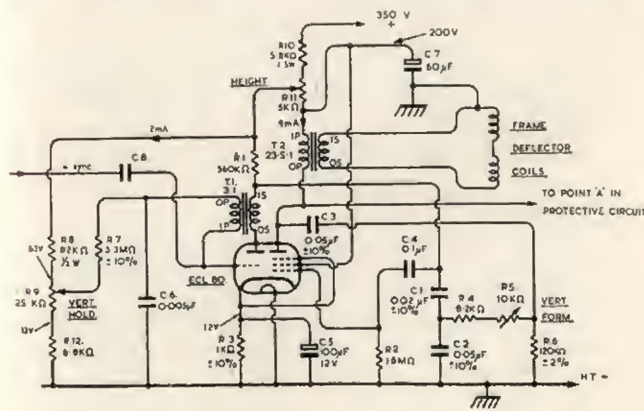


FIG. 8.—FRAME TIME-BASE GENERATOR CIRCUIT.

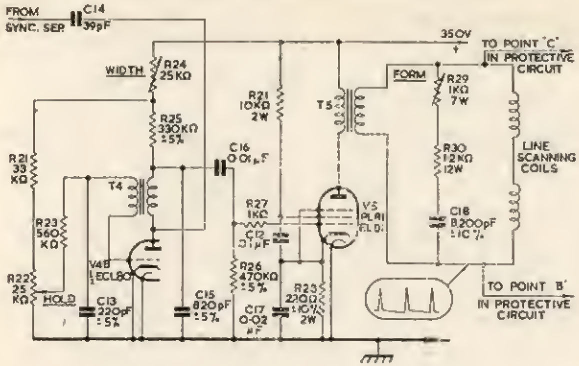


Fig. 9.—Line Time-base Generator Circuit

A suitable circuit for frame scanning, using an ECL80 triode-pentode, a silicon–iron-cored blocking oscillator transformer and a 23·5 : 1 output transformer, is shown in Fig. 8.

The circuit has ample reserve of scan, and draws a total current of 13 mA only from the 350-V H.T. line.

Indications of the currents and potentials appearing in the circuit are also given in Fig. 8.

Line Time-base Generator

The line-deflection coils require 825 mA peak-to-peak to scan fully, and have an inductance of 3·24 mH.

A projection receiver employing the Mullard 25-kV E.H.T. unit normally has a 350-V H.T. line available for the line time-base, and there is therefore little advantage in employing an energy-recovery system.

A suitable circuit employing the triode section of an ECL80 as blocking oscillator and a PL81 as output valve is shown in Fig. 9.

Protective Circuits

If either of the time-base units should become inoperative, the high-velocity electron would destroy the screen surface along a line which would be horizontal or vertical according to which time-base was out of action. Means must therefore be provided to cut off the beam in the event of the failure of either or both the time-base units. A circuit possessing all the necessary characteristics would be very complex, and it is therefore necessary to make some compromise. The circuit shown in Fig. 10 has the advantage of simplicity and also has the essential characteristics.

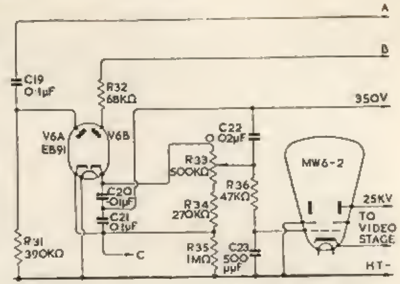


Fig. 10.—Protective Circuit in Conjunction with an EF80 Video Output Stage.

The voltage appearing at the anode of the frame-output valve (Point A in Fig. 8) is taken via a capacitor–resistor coupling to one diode anode (V6A) of the double diode V6, type EB91. A potential of approximately 90 V positive to the chassis is obtained across resistor R35.

The end of the line-deflection coils at which the flyback pulse is positive-going (Point B in Fig. 9) is connected via a limiting resistor R32 to the second anode (V6B) of V6, and a steady potential of at least 150 V is produced across resistors R33 and R34. R33 is the brightness control, and its slider is connected to the picture-tube grid via resistor R36. This sets the grid of the picture tube over a range of potentials suitable for a brightness control when the cathode of the picture tube is taken to the anode of the video valve as shown in Fig. 6.

If the frame circuit fails, the potential at all points on the chain R33 and R34 falls by 90 V—sufficient to cut off the picture tube. Similarly, if the line circuit fails, the total voltage across R33, R34 and R35 falls by 150 V, and the proportional change at the grid of the picture tube is again sufficient to cut off the tube.

This circuit is suitable for use in the video stage employing an EF80. It does not, however, provide adequate protection with a video stage employing a PL83. This is due to the lower mean anode potential of the PL83, and also to the greater video-drive voltage applied to the cathode-ray tube. For this reason the circuit shown in Fig. 11 has been devised.

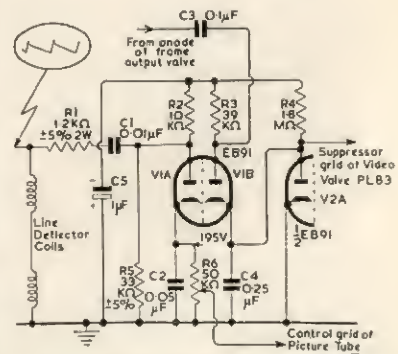


Fig. 11.—Protective Circuit in Conjunction with a PL83 Video Output Stage.

In this circuit the end of the line-deflector coils at which the

flyback pulse is positive-going is connected to the anode of the diode V1A via a limiting resistor R1 and coupling components C1 and R5. The positive, rectified output from the diode cathode is utilised by the brightness control R6, which supplies the grid potential of the picture tube. Thus, a failure of the line time-base biases the picture tube beyond cut-off. The coupling components C1 and R5 are included to ensure that a waveform with a mean component negative to earth appears at the anode of the diode V1A. This mean potential is applied, via the smoothing components R2, R4 and C4, to the suppressor grid of the video valve. In the absence of any other applied potential, the anode current of the video valve is then cut off and the picture tube, having its cathode connected directly to the anode of the video valve, receives no signal and assumes the positive potential corresponding to that of the H.T. supply. The beam is therefore cut off.

Under normal working conditions, however, a positive potential derived from the frame time-base circuit via the coupling components C3 and R3 and the diode V1B restores the suppressor grid of the video valve to approximately cathode potential. If the potential derived from the frame time-base is established before that derived from the line time-base there will be a tendency for the suppressor grid of the video valve to go positive, thereby causing secondary emission, which, in turn, will cause

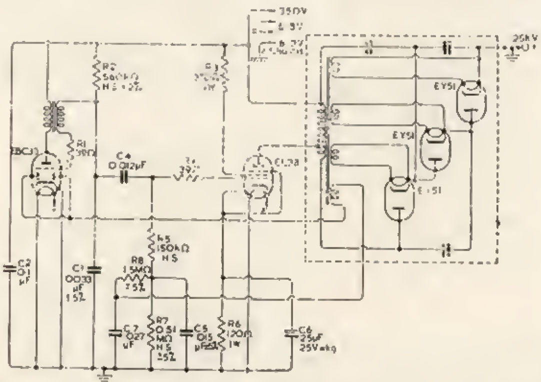


FIG. 12 (a).—EARLY MULLARD E.H.T. UNIT FOR PROJECTION RECEIVERS.

This unit provides a regulated supply at 25 kV by means of the triode section of an EBC33 1,000-c/s blocking oscillator driving an EL38 amplifier which produces anode pulses in the order of 8–9 kV: a voltage-tripler circuit using three EY51 rectifiers produces the full E.H.T. Voltages across the additional winding on the "ringing" transformer are rectified by the diode sections of the EBC33 and fed to the grid of the EL38 for automatic voltage regulation, which is effective with outputs up to 250 μA.

the suppressor grid to become more positive until "blocking" occurs. A third diode V2A is included to eliminate this risk.

From the foregoing description it is seen that when both time-bases are operating the picture tube is correctly biased and

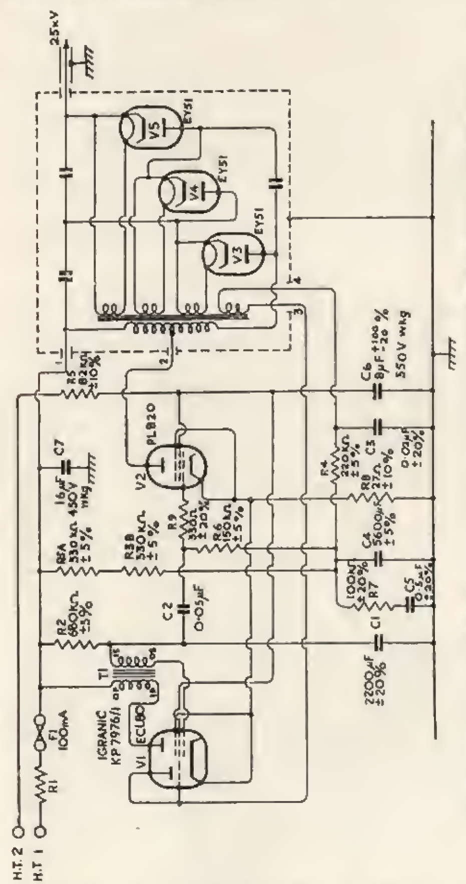


FIG. 12 (b).—LATER VERSION OF THE MULLARD E.H.T. UNIT FOR PROJECTION RECEIVERS.

The principle of operation is similar to that of the unit shown in Fig. 12 (a). The pentode section of V1 is the oscillator, which drives the amplifier V2. V3, V4 and V5 form a voltage tripler circuit. The triode section of V1, diode connected, is in the automatic voltage regulation circuit.

fed with signal. If the frame time-base fails the picture tube is cut-off by its cathode going positive, and if the line time-base fails the picture tube is cut off by its grid going negative.

This circuit relies for its operation on a comparatively large

change in the anode potential of the PL83, which occurs between the quiescent and cut-off conditions, and is unsuitable for use with a video stage employing an EF80, in which the change of anode potential is not sufficient to provide adequate tube cut-off.

H.T. Power Supply Unit

The requirements of the E.H.T. unit in large measure determine the design of the H.T. power-supply unit in a projection television receiver.

The E.H.T. unit must be supplied at 350 V from a source having a resistance of between 250 and 550 ohms. It will draw from 25 to 55 mA, according to the picture content.

A 350-V1 H.T. line is often provided by means of an overwinding on the mains transformer.

Typical E.H.T. circuits are shown in Figs. 12 (*a*) and 12 (*b*).

ADJUSTMENTS

Projection Television Focusing

In a direct-viewing television receiver focusing is a matter of adjusting the current through the focusing coil or, in the case of permanent-magnet focusing, adjusting the permanent magnet on the neck of the tube. In projection television, however, in addition to accurate focusing of the picture on the face of the cathode-ray tube, it is necessary to adjust the position of the

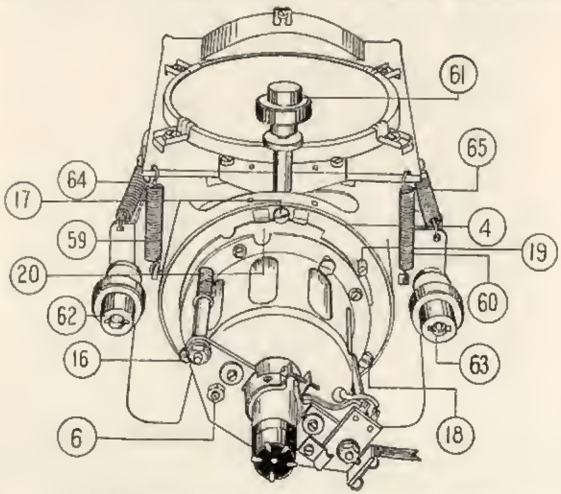


FIG. 13.—ADJUSTMENTS FOR MECHANICAL FOCUSING.

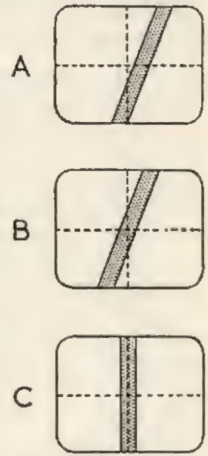
face of the tube with respect to the spherical mirror to ensure that the picture is accurately focused on the viewing screen. Focusing a projection television receiver is also a simple operation, provided it is tackled in the right way. It should preferably be carried out while a test pattern is being transmitted. It can, however, be done when no signal is available, the image then consisting only of the scanning lines.

If the picture is hopelessly out of focus the normal electrical focus control must first be adjusted, but if it is found that a strip of picture is already in correct focus, only the mechanical adjustment described below need be made.

Note that these instructions, and Fig. 14, refer to a picture which emerges from the corrector lens with the scanning lines

FIG. 14.—SUCCESSIVE STAGES IN MECHANICAL FOCUSING.

The shaded area represents strip of picture in focus.



parallel to the axis of the tube. In some receivers the lines may be at some other angle. This will result in the strip of picture which is in focus being at a different angle from that shown in Fig. 14, but does not affect the method of adjustment.

(*a*) Remove the red locking plate from the front of the optical unit by withdrawing four screws, see Fig. 13.

(*b*) Slacken the knurled lock-nuts of screws 61, 62 and 63.

(*c*) Turn screw 61 to one extremity of its travel. This results in a narrow strip of picture only being in focus (see " A ", Fig. 14) if the raster is correctly focused on the face of the cathode-ray tube. If a strip of picture is already in correct focus on the viewing screen, operation (*c*) may not be necessary.

(*d*) Turn screws 62 and 63 *simultaneously in the same direction* until the strip of picture which is in focus passes through the exact centre of the picture (see " B ").

(*e*) Turn screws 62 and 63 in *opposite directions* until the strip of picture which is in focus is both central and vertical (see " C ").

(*f*) Adjust screw 61 until the strip of picture which is in focus widens and ultimately covers the whole picture area, and adjust for best results.

(*g*) Tighten the knurled lock-nuts of screws 61, 62 and 63.

(*h*) *Do not* replace the red locking plate, as this may throw the focus out of adjustment. The locking plate with its four screws should, however, be preserved for use if the receiver has to be sent away for service.

Centring Picture on Tube Face

The face of the picture tube should be viewed through the corrector plate. Slacken off the focus-coil locking-screw, which is sometimes painted red and is situated very near to the picture-tube retaining clip. Adjust the two hexagonal-headed bolts on the flange of the focus coil until the picture is exactly central on the tube face. Tighten the focus-coil locking-screw, taking care not to alter the position of the focus coil.

Picture Centring on Screen

If the picture is not central on the screen (but is central on the tube face) slacken the two wing-nuts locking the optical unit levelling screws. Adjust the screws appropriately: the left-hand screw moves the picture vertically, and the right-hand one moves the picture horizontally.

Cleaning Projection Mirrors

Occasional cleaning of the front aluminised mirror of projection television receivers may be necessary in order to obtain a clear picture. The treatment to be adopted largely depends upon the state of the mirror, but the following methods have been suggested by Mullard, Ltd.

(1) If the dust is loose, the mirror should be carefully brushed with a very soft brush.

(2) If the surface of the mirror is at all cloudy, the surface should be washed with a detergent such as Lissapol solution, and afterwards rinsed with distilled water, preferably allowing the surplus liquid to drain off. Only soft cotton-wool should be used to apply the detergent solution, and for removing the surplus liquid, should time not permit draining.

(3) If the surface is greasy, then it may be necessary to use a solvent such as benzene, finally drying with best-quality soft cotton-wool.

Projection E.H.T. Dangers

The 25-kV electron beam of projection models produces soft X-rays, which are normally shielded from the operator by the optical box. Should it be necessary to operate the cathode-ray tube outside of the optical box, it is recommended that a lead-glass shield be used. The equivalent lead thickness of the shield should not be less than 0·5 mm.

This article has been compiled largely from information supplied by Mullard, Ltd., on their projection television system as used in a number of sets made by various manufacturers.

[SECTION 7]

BAND III CONVERSIONS

ALL domestic television receivers produced to-day are fitted with tuning arrangements which allow the viewer to select any of the Channels in Band I or III.

A fair number of older receivers in daily use, however, are limited to the reception of Band I channels and, in some cases, to the reception of a single channel only.

These receivers fall into two categories, superheterodyne and T.R.F. The superhet receiver, generally, will tune to any one of the five Band I channels. The intermediate frequency used will vary according to the manufacturer, see list on page 199. T.R.F. receivers will receive only one channel in Band I.

It is to these older receivers that conversion methods must be applied.

Some receiver manufacturers have made available converters for certain of their models. No difficulty should be encountered in fitting these, as provision will, generally, have been made in the receiver to allow this converter to be readily installed.

As with receivers, so converters fall into two categories: (i) "Aerial to I.F." converters; and (ii) "Band III to Band I" converters, often referred to as "Universal" converters. Both types have their particular application, but where a choice between the types may be made the "Aerial to I.F." type of converter is strongly to be recommended. The reasons will become apparent later.

CONVERSION OF T.R.F. RECEIVERS

The number of T.R.F. receivers likely to require conversion is probably small; but when one is encountered certain problems may arise of which it is as well to be forewarned.

The type of converter required for this application is the "Band III to Band I"; these are readily available in both assembled and kit form.

The unit functions as follows. Band I and Band III signals are supplied to the unit from the respective dipoles by means of separate co-axial cables, sockets being provided on the unit as a means of connection. A switch is provided so that the user may select his Band I or Band III programme. When the normal Band I programme is selected the Band I signal from the aerial is switched through to the converter output socket, whence it is connected by co-axial cable to the aerial input

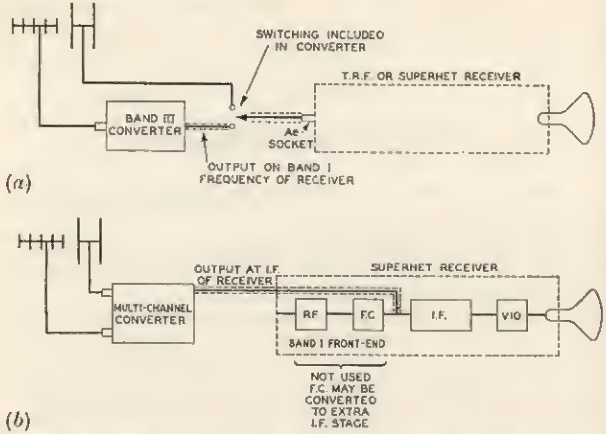


Fig. 1.—The Two Basic Methods of Conversion: (a) Band III to Band I, in which the Converter Converts the Band III Signals to the Band I Frequency of the Receiver, Feeding into the Receiver Aerial Socket; (b) Aerial to I.F., in Which the Converter Converts the Band III Signals to the Receiver I.F., Replacing the Receiver R.F. and F.C. Stages.

terminals of the receiver, which then functions in the same manner as before conversion, as the signal will not have been affected by its passage through the converter.

When the alternative programme in Band III is selected the Band I signal is disconnected from the receiver. The Band III signal is applied, via a tuned matching transformer, and usually an R.F. amplifier stage, to the grid circuit of a valve acting as a signal mixer; this valve mixes the Band III signals with the output from a local oscillator, which is often in one envelope with the mixer section or may be of the self-mixing type. The local oscillator frequency is adjusted so that when heterodyned with the Band III signal input a difference frequency similar to the Band I frequency in use in the television receiver is produced at the anode of the mixer valve. The anode circuit is tuned to this frequency and a further matching transformer passes the converted signal to the output sockets of the converter.

This signal will now be handled normally by the receiver, but, of course, the programme material will be that of the Band III transmission.

Power Supplies

Converters of the type under discussion are usually marketed as units with their own power supplies. If it is decided to instal

a unit to draw its power from the television receiver the following points should be noted:

(a) The receiver power supply must be capable of supplying the extra load.

(b) If the receiver has, as usual, a mains connected chassis, then the converter chassis will also be mains connected. This is a dangerous arrangement unless the converter is specifically insulated for such usage.

(c) The valves used in the converter must have heaters of voltage and current rating suitable for inclusion in the heater chain of the receiver.

Upper Sideband Receivers

A pitfall peculiar to Channel I (London) may be encountered when converting the older T.R.F. receiver. This is as follows: It was not uncommon for the input circuit of the receiver to be designed to accept the full double sideband response of the old Alexandra Palace transmitter. Thereafter the sound signal was taken off and amplified in the sound R.F. strip, the vision signal then being passed to the vision R.F. stages, which were aligned to accept the upper sideband only. The advantage of this arrangement was that good sound rejection on vision could be achieved without sound traps.

This type of receiver will not accept lower sideband transmissions without serious degradation of the picture. As all

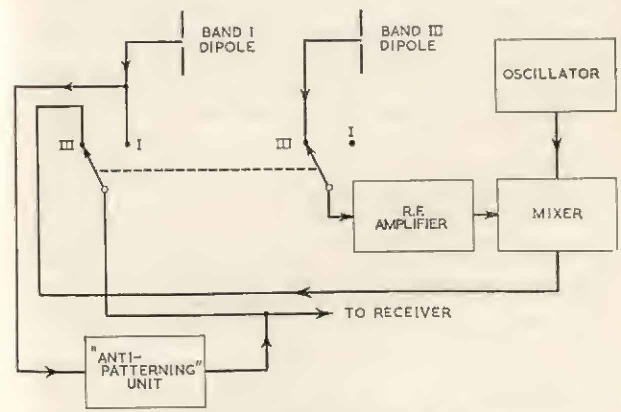


Fig. 2.—Showing the Band I/III Switching of a Converter with "Anti-patterning" Unit Added.

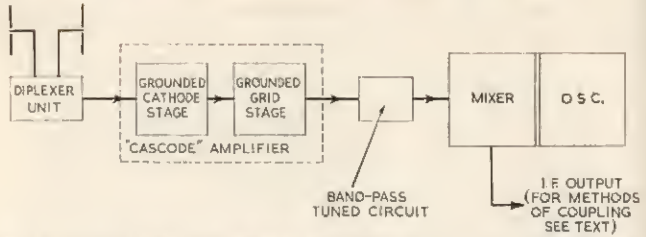


FIG. 3.—BLOCK SCHEMATIC DIAGRAM OF AN "AERIAL TO I.F." BAND III CONVERTER. "UNIVERSAL" CONVERTERS USE THE SAME BASIC ARRANGEMENT.

stations now radiate single-sideband transmissions this type of receiver is not really amenable to conversion. It may be possible to re-align the receiver to accept more of the lower sideband, but, if this were done, the probability is that rejection of sound on vision would be poor, and it would become necessary to insert sound-rejector coils.

Patterning

Although it is necessary to use the above type of "Universal" converter for T.R.F. receivers, they have inherent disadvantages which make them unpopular for general use. The first is that when the receiver is accepting a signal from the converter, containing Band III programme material, it will also accept a Band I signal introduced by a lead or by direct pick up. In this case the two programmes are seen superimposed one upon the other, and this in bad cases makes viewing impossible. In the less serious cases a background pattern will be observed.

When the receiver is accepting a Band I signal from the converter the Band III signal and the conversion action are switched out; the Band I picture therefore is "clean". Any lead or direct pick-up of Band III signal is not accepted by the receiver.

Secondly, the converted Band III output from the unit, since it is at the frequency of the local Band I station, is a potential source of interference to neighbouring receivers on the Band I channel, particularly after it has been amplified in the main receiver. The signal may be radiated in several ways, from the co-axial cable connecting the converter to the receiver, from the R.F. circuits of the receiver itself or by inductive or capacitive coupling, within the converter, to the aerial input circuits and thence to the dipoles.

This latter type of radiation condition is much reduced if an R.F. stage is incorporated in the converter circuitry, as it acts as a buffer between the mixer grid circuit and the aerial.

A unit has been marketed which is designed to remove the Band I "break-through" when viewing a Band III picture.

This is achieved by introducing a sample of Band I signal to the required signal such that it is 180° out of phase with the Band I interference and thus cancels it out. Controls are provided to enable adjustment of the phase and amplitude of the correction signal.

This unit, however, does not reduce interfering radiation from the installation into neighbouring receivers.

CONVERSION OF SUPERHETERODYNE RECEIVERS

Many thousands of this type of conversion have been successfully carried out, with complete satisfaction to the user, since the start of alternative programme broadcasting.

Converters for superheterodyne receivers should be of the "Aerial to I.F." type if the most satisfactory performance is to be attained. The majority of these incorporate a twelve- or thirteen-channel switch so that programme selection is simple and facility is available for the reception of further channels in Bands I and III if required, should the user move to a district served by different channels. These tuners are similar in design to those used in multi-band receivers. Attached to the converter are generally two leads up to several feet in length to provide the method of connection of the converter to the receiver. Pre-set gain controls, one each for Bands I and III, are provided so that similar intensity pictures may be obtained without resorting to adjustment of the receiver.

The method of installation and coupling of the I.F. signal to the receiver varies according to the manufacturer, two methods of coupling being shown in Fig. 4.

In most cases the installation is carried out as follows. The R.F. amplifier and mixer valve of the receiver are removed and replaced with the plugs provided on the extended leads from the converter. Power is taken from the R.F. valve socket, the I.F. output from the converter being injected into the mixer valve socket.

Thus the normal R.F. tuning of the receiver has been replaced by that of the converter with the facility to select any channel, the I.F. amplifiers of the receiver remaining unchanged. The receiver may now, in fact, compare very favourably in performance and facilities with much later models.

Means are generally provided to secure the converter inside the receiver cabinet so that the only external projection is that of the station selector knob. Some converters are offered with a small case which permits the unit to stand external to the receiver, the two leads to the receiver being arranged in the most suitable way. Remarks on safety precautions apply here also, and care should be exercised to ensure that the converter manufacturers' instructions on installing are closely followed to ensure that no "live" parts of the equipment are available external to the receiver cabinet.

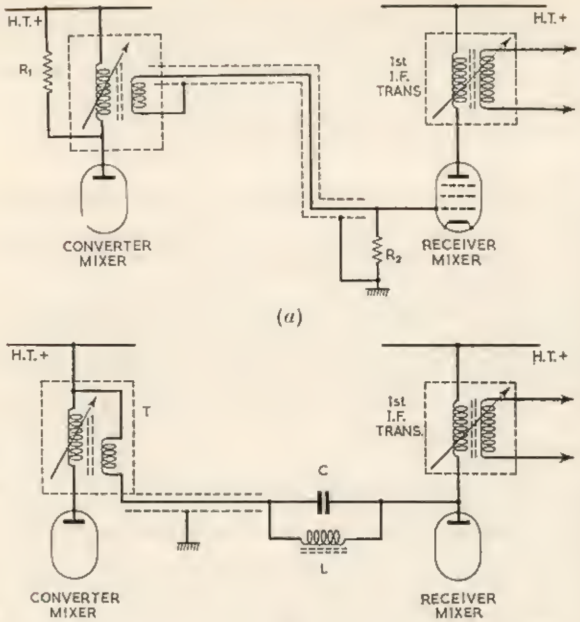


FIG. 4.—ALTERNATIVE METHODS OF COUPLING "AERIAL TO I.F." CONVERTER TO RECEIVER.

(*a*) Coupling to the grid of the mixer. The low gain of this arrangement is compensated by the fact that the receiver mixer acts as an I.F. amplifier. R2 is a low value terminating resistor.

(*b*) Capacity coupling to mixer anode. Because of the high impedance of this coupling, the gain is such that it is unnecessary for the receiver mixer to act as an I.F. amplifier.

Converter Specification

A great number of design differences exist between the receivers which are normally presented for conversion, and a number of these require to be known before a converter of the correct specification can be obtained.

The information required is as follows:

(*a*) type of valve heaters in use, *i.e.*, series or parallel wired. If in series, then the current rating will be required; if in parallel, then the voltage rating will be required;

(*b*) the intermediate frequency of the television receiver;

(*c*) whether the oscillator of the receiver, before conversion, is higher or lower than the signal frequency;

(*d*) in the case of tuners with clip-in coils it will be necessary to specify the channels it is required to receive.

In many cases the converter manufacturer will recommend his product for specific receivers, in which case the above information need not be known, and quotation of the converter catalogue number is sufficient. A number of receivers, particularly fringe-area models, were fitted with two R.F. stages preceding the mixer. In order to carry out a conversion one method is to remove only the two R.F. amplifier valves, leaving the mixer *in situ*. The converter power lead is then plugged into one of the vacated valve-holders. The converter I.F. output is coupled into the grid of the mixer valve, which then assumes the role of an I.F. amplifier. The oscillator of the receiver is then prevented from functioning, possibly by removing its H.T. supply.

By using the converter in this fashion the overall gain of the receiver is maintained and power taken from the receiver is more nearly that normally supplied.

Conversion Problems

The position of the converter heaters in the heater chain of a universal-mains type of receiver may require consideration. Some receivers have their R.F. and mixer valves relatively "high up" the heater chain, that is to say away from the ground. This may give rise to modulation hum troubles on some conversions, and the cure is to rewire the converter heaters (plugged into R.F. amplifier and mixer valve-holders) "down" the chain, nearer to chassis.

Another fault, commonly encountered but mystifying on first acquaintance, is as follows: A picture is obtained, after conversion, but no sound can be obtained; tuning the converter oscillator control will bring in the sound but cause the picture to disappear. The trouble is that an incorrect type of converter has been obtained. The receiver oscillator has, for example, been working on the low side of signal frequency, whereas the oscillator in the converter is working on the high side of signal frequency. Or, conversely, the receiver oscillator may have been on the high side and the converter on the low.

Reference to Fig. 5 will help to clarify this point. If the I.F. response "A" is considered to be that of a converter coupling circuit and the response "B" that of a receiver I.F. amplifier; also the converter is considered to have its oscillator frequency higher than signal frequency, and the receiver, before conversion, had its oscillator below signal frequency; then, by tuning the converter oscillator, response "A" can be made to move through response "B". If, now, the two sound carriers are set one upon the other a sound signal will be heard, but it will be observed that the vision signal-carrier frequencies do not correspond and,

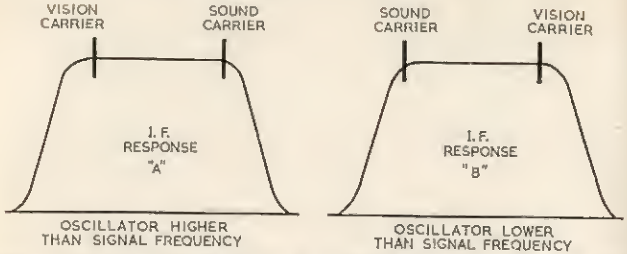


FIG. 5.—IDEALISED I.F. RESPONSES WITH OSCILLATOR WORKING HIGHER AND LOWER THAN SIGNAL FREQUENCY.

therefore, no picture will result. Again, if the vision-carriers are superimposed by this means and a picture obtained, then the sound-carrier frequencies do not coincide and no sound signal is heard.

When the installation is complete it is good practice to make voltage and current measurements in the section of the receiver affected by the conversion. A few simple calculations will quickly indicate whether abnormal conditions exist in the receiver, and, should this be so, these conditions should be "cleared" before the conversion is considered complete.

U.H.F. Reception

Techniques for reception on Bands IV and V differ in several respects from those used on Bands I and III. "Coils" are often replaced by tuned lines, which may be in the form of co-axial trough-line elements, while even when retained the coil may comprise little more than a hairpin of stout wire. Cascode r.f. amplifiers are not suitable for Band V and the r.f. stage, where fitted, is usually of the grounded-grid type; it is quite common however to omit this stage altogether. Silicon crystal diodes are generally used as mixers. Oscillator stability is a problem and two solutions are possible; one is to include voltage regulation as well as temperature compensation; the other is to run the oscillator on a much lower frequency and to include a harmonic generator (which may simply be a crystal diode) between the oscillator and the mixer.

[SECTION 8]

INSTALLING AND SERVICING RECEIVERS

INTRODUCTION TO FIELD SERVICING

by E. C. HOWELL, M.Brit.I.R.E., A.I.E.E.

TELEVISION installation and servicing work demands qualifications of a type different from those normally associated with engineering, or with work carried out in the workshop under the direct supervision of senior staff. The television servicing engineer is brought into close association with the general public to a far greater extent than his radio colleague; this is partly because the modern television receiver is not an easy instrument to transport by van, and partly because owners are loath to part with their receivers if they feel that it is at all possible for repairs to be carried out on the spot. For these reasons, the service engineer—if he is to improve the prestige of his firm and his occupation—is called upon to combine the qualities of a first-class technician with those of a sales manager: as essential as knowledge of television technique is a good working knowledge of human psychology.

If such requirements appear to be setting a high standard, then it is rightly so, for to meet the rapidly expanding demand, there is unlimited opportunity for men of the right calibre who are capable of handling people as well as expensive and intricate test equipment, and who seek work that provides a constant variety of surroundings coupled with ever-changing technical problems.

It is the purpose of this introduction to underline the personal rather than the technical problems, which are dealt with elsewhere in this book.

Obviously it is a prime requisite that the engineer must have a first-class knowledge of the apparatus that he is called upon to repair; detailed knowledge of the finer points of a particular design comes only from constant handling of similar types of equipment. New models and new circuits are constantly being introduced which require reference to technical literature and circuit diagrams, but it is bad psychology to pore over technical data too long in the presence of the customer, who may be only too ready to suspect that this means the engineer "does not know his job". When called in to service a model that is unfamiliar try, wherever possible, to study all available literature beforehand.

Tact

The field engineer must be prepared to learn something from the proven technique of sales personnel: he must be well spoken, polite, tidy, tactful and above all must not become annoyed with a difficult customer. Not only is confidence created, but attention to such points will make for a better atmosphere in which to work. It is of little use being a "genius in dirty flannels" when calling on a house-proud housewife; nor will she be pleased if wrappings and other bits of paper are left for her to clear up, and her carpets littered with cigarette ash and bits of wire. Remember also that first appearances count for much, and dirty shoes and open collars seldom inspire confidence.

Tactfulness is difficult to define but worthy of cultivation if not already possessed as a gift. From a service engineer's viewpoint, it consists largely of "saying nothing at the right moment". If he has received wrong instructions from his office, or some misunderstanding has occurred, he should be careful not to run down his firm to the customer. He must offer to "look into the matter at once", and then diligently do so. Never belittle the customer's set, even if it is a little outdated or poorly constructed. Owners are extremely sensitive to such criticism, which does, after all, tend to reflect on their original choice of the set; explain, if necessary, that new improvements have been made recently and are incorporated in the latest models.

Generally, it is not the field engineer's job to discuss charges, and he should be most wary in exceeding his authority by suggesting a "possible price". Similarly, he should not make *any* promises to customers without obtaining authorisation from his office; but promises and appointments, once made, must on all accounts be kept. Should it be impossible to keep an appointment, the customer must be advised and not left waiting for an engineer who never arrives.

Records

Care must also be taken in entering up "job cards". Abbreviated remarks such as "F.O.T. rep. N.U.G., etc." may be satisfactory if they are part of a definite code recognised by the office staff, but if not are liable to lead to wrong charges, and to loss of confidence by the customer, who generally has a fair idea of what has been done.

Remember that the engineer represents his company, and the loss of customers due to carelessness or faulty work not only affects the livelihood of the engineer concerned but also that of all other persons employed by his company. On the other hand, a fully satisfied customer reflects ultimately on the standing of all concerned; and leads to the advancement of the service engineer.

E. C. H.

INSTALLATION

The first point to be considered is the best position in the room where a receiver is to be installed. If possible, the screen should be situated so that light does not fall directly on to it. It is advisable to provide a low-wattage lamp, as viewing in a completely darkened room causes eye-strain. The mains lead and aerial down-lead feeder should be placed where they are not likely to be damaged in any way, and the latter should be kept as short as possible.

The mains supply socket must be rated at least 2 A, and a television receiver must always be adjusted to suit the supply. The frequency of A.C. mains supplies should be determined, and the correct rating of the mains supply fuses is another important consideration. A step-up auto-transformer may be used where the A.C. mains supply is of lower voltage than that for which the receiver is intended. A.C./D.C. receivers will operate from D.C. supplies only when the plug is inserted into the supply socket the correct way round.

Earth leads should be of heavy gauge wire, and must be kept as short as possible. A copper earth tube or plate, with a large surface area and going deep into damp ground, is best. A main cold-water supply pipe may be used, but gas, hot-water or telephone installations must on no account be used. Most television receiver chassis are at mains potential, and direct connection to the chassis should never be made.

ADJUSTING CONTROLS

The controls provided in a modern television receiver fall roughly into three categories: the main user controls, mounted at the front, side or top of the receiver; auxiliary controls, such as those for the time-bases, which are pre-set but which can generally be readily adjusted either by the user or by the engineer; and finally, those which can be adjusted only with the protective cover removed and which may require the changing of soldered tappings, etc. With the development of circuits which are less subject to variation with changes in mains voltages, ageing of valves, etc., there is a tendency for this third category to increase: for example, focusing, width and line linearity are now often intended for adjustment only by the engineer.

Time-base Controls

The controls usually found are the line and frame hold, the line and frame linearity (sometimes called line and frame form), the width (sometimes called line-amplitude) and height (sometimes called frame-amplitude) controls. In many receivers two frame-linearity controls are provided, one affecting the top of the picture only.

The correct procedure is first to adjust the frame- and line-hold controls to give a steady raster—a picture that tends to

break into vertical strips or to move up or down indicates that an adjustment of one of the hold controls is necessary. Roughly centre the picture by the centring magnets on tube neck. Next adjust the width and height controls so that the picture just fills the screen. Then adjust the linearity controls to compensate for any irregularities, such as cramping, in the picture. Where two frame-linearity controls are provided, the one affecting the top of the picture only should be adjusted first, the overall control being adjusted last. It is sometimes desirable, in order to achieve good linearity, to adjust the height and width controls so as to overscan the tube face when making adjustments to the linearity controls. After adjustments to the time-base amplitude and linearity controls it will often be necessary to re-centre the picture.

In some models which include flywheel line synchronisation, a switch is incorporated in the line hold control, and in such cases the knob of the control must be depressed before it can be rotated. Pre-set line hold controls are also common on such models. The usual practice in adjusting these is to set the main hold control to mid-travel, short out the line sync. pulses (in some cases it may be easier to remove both the frame and line sync. pulses), and adjust the pre-set control so that the picture is synchronised (or slowly running through if the frame sync. pulses have been removed). The width and line linearity controls may need slight readjustment afterwards. In some models provision is made to short-circuit completely the flywheel circuit when the set is used in an area of good signal strength; this makes the setting of the line hold control less critical.

In most modern receivers the line linearity control takes the form of a shorted-turn loop, which is fitted beneath the deflection coils, around the neck of the picture tube. This device may also be used to control the width. Further information on this type of control is given in the basic circuitry section.

Interference and Sensitivity Controls

Two other pre-set controls usually found are the vision-interference limiter and the sensitivity control.

The vision-interference control may take the form of a pre-set potentiometer or a plug and socket adjustable in a number of fixed steps. Most forms of limiter, when set to give maximum clipping, will cause some flattening of the highlights of the picture. Vision-interference limiters should therefore always be adjusted to the minimum clipping position consistent with satisfactory reception.

A sound-interference limiter adjustment is provided in a number of sets: as with vision interference limiters, the adjustment should be set to give the minimum limiting action consistent with freedom from interference.

The sensitivity control is fitted to vary the gain of the receiver so that it may be adjusted to suit the signal strength of the area

in which it is installed. If the signal strength is too great, sound-on-vision and vision-on-sound interference may be caused, and the sensitivity control will in such conditions need to be reduced so that the interference is eliminated.

Miscellaneous Pre-set Controls

Other pre-set controls commonly fitted are for picture quality, line anti-striation and line drive adjustment. The picture-quality control usually takes the form of a compression trimmer or other arrangement for increasing or decreasing the capacitance in the cathode circuit of the video output valve. This control should be adjusted to give a sharp picture, free from smear, a compromise in some locations having to be sought between Bands I and III transmissions.

Line anti-striation or balancing trimmers are fitted on the deflection coils to balance the stray capacitances in the coils. The adjustment of this is normally carried out in the factory, and should only need readjustment if new deflection coils are fitted. The adjustment is for minimum waviness in the line scanning.

Line drive controls usually consist of a trimmer controlling the drive to the line output valve, and should need no adjustment unless valves in the line time-base are changed. The usual method is to adjust the control so that the E.H.T. voltage is a given value, as specified by the manufacturers. If out of adjustment, a faint white line may appear near the centre of the screen. Damage to the line output valve or transformer can be caused if this adjustment is not correctly carried out.

In fringe areas it is advisable to adjust the pre-set controls for average signal-strength conditions, as in these areas a certain amount of fading is to be expected, and unless some such allowance is made they will require constant attention.

Mechanical Picture Adjustments

Around the neck of the picture tube are situated the deflection coils and also usually several magnets for such purposes as centring and focusing the picture, and for reducing ion burn.

The deflection coils are housed close up against the bulb of the picture tube, and may be rotated, after loosening the clamping screws, so as to level or square the picture. Correction magnets may also be found fitted against the bulb of the tube to correct for barrel and pin-cushion distortion, etc., and to remove corner shadowing. Behind the deflection coils are situated magnets controlling the focusing (if magnetic focusing is employed) and centring of the picture. These are adjustable by means of suitable levers or knobs. At the rear of the picture-tube neck is frequently fitted an ion-trap magnet. The adjustment of this is dealt with below.

Adjusting Ion-trap Magnets

Ion-trap magnets are normally secured to the neck of the tube by means of a clamp, and to facilitate fitting there is usually an arrow stamped on the magnet, and a line along the neck of the tube. The magnet is normally fitted above the neck with the arrow pointing in the direction of the screen, but alternatively may be fitted with the magnet underneath and the arrow pointing away from the screen. To fit and adjust the ion-trap magnet, the following procedure should be followed, preferably when a stationary test pattern is available.

With all power switched off, and reservoir condensers discharged if necessary, the magnet is pushed over the base of the tube with the arrow pointing towards the screen, and placed immediately over the line marked on the tube neck. The cathode-ray tube socket is then replaced, the receiver reconnected to the mains supply, ensuring that the chassis is not above earth potential, and the brightness control set to a position where the raster is just visible. To achieve this, it may be necessary to adjust the position of the magnet slightly.

Then with the arrow over the line, the magnet is moved towards the screen until the focused raster is at its brightest. The brightness control is then re-adjusted until the peak-white portions of the image are at a correct level, and, if necessary, the position of the magnet adjusted slightly to obtain maximum brilliance.

Where the picture cannot be centred by adjusting the position of the focus field, the ion-trap magnet may have to be rotated slightly around the neck; this operation, however, should not lead to any decrease in brilliance.

When the picture fulfils the above requirements, lock the magnet in position by tightening the thumbscrew, ensuring that the magnet does not change position while this is being done.

Should it not be possible to obtain a position of maximum brilliance, it may be necessary to substitute another magnet. The magnet should never be adjusted to remove a shadow if this involves reducing the brightness of the picture; this should be done by adjusting the focus coil and/or deflection coils.

Always handle an ion-trap magnet with care: it should not be subjected to strong magnetic fields or mechanical shocks. It should not be allowed to come into contact with metallic objects.

Steering Magnets

Apart from picture correction magnets positioned close to the flare of the tube and centring magnets around the neck of the tube, a steering magnet (sometimes known as a "beam centring magnet") in the form of a circlip is often fitted around the neck of the tube for the purpose of ensuring that the electron beam is central within the final aperture.

Whether or not a steering magnet is required is judged by the

quality of the picture. A general smudginess of "tails" on white spots may be an indication of the need of a magnet, though these faults can be caused by incorrect alignment of the receiver circuits. On some picture tubes where the steering magnet is not required it may nevertheless be fitted, usually at the extreme end of the tube neck, where is has no influence on the electron beam. The magnet should not be discarded, as it may be needed should the tube be changed. In practice, the steering magnet is used for much the same purpose as the final adjustment of an ion-trap magnet on a bent-gun tube, that is to say for general picture quality rather than for brightness. The setting is determined by rotational and axial movement along the tube neck to a position which gives optimum freedom from blurring of leading edges. The adjustment should be carried out on Test Card "C" so that the resolution can be judged over the whole screen.

User Controls

The controls usually provided for operation by the owner are the brightness, contrast, volume and, sometimes on older models, focus controls. The following procedure, which assumes that the pre-set controls are correctly adjusted, may be followed when adjusting these controls:

(1) Switch on the receiver fifteen minutes before the start of the programme, so that the receiver has time to warm up to normal working temperature. It is not, of course, necessary to allow so much time ordinarily, but it is advisable when full adjustment is being made.

(2) When the tuning signal (see later) appears, turn the contrast and brightness controls to minimum.

(3) Increase the brightness slowly, until a very faint glow is just visible on the screen. Then reduce it very slightly until the glow just disappears.

(4) Increase the contrast until the topmost shapes on each side of the circle in the tuning signal are white, and the shapes immediately below them are light grey.

(5) Readjust the brightness control so that the bottom shapes are black and the shapes immediately above them are dark grey.

(6) Make a slight adjustment to the contrast control to get the best contrast between the white and the light grey shapes.

(7) Adjust the focus control, if fitted, to give the clearest definition to the vertical lines in the centre of the picture.

The effects of the brightness and contrast controls on the pictures are interdependent, and it is for this reason that the successive adjustments to them are recommended. If the correct relative adjustment of these two controls is not found, the brightness control will need readjusting whenever the overall brightness of the scene changes. With a constantly changing scene, as is usual during the programmes, it is very difficult to

FIG. 1.—THE B.B.C. TUNING SIGNAL.
(*Courtesy B.B.C.*)

arrive at the best relative settings for the brightness and contrast controls.

A suggested method is first to turn both controls to minimum. Increase the brightness slowly, until a very faint glow is just visible on the screen. Then reduce it very slightly until the glow just disappears. Increase the contrast to give whites and light greys. Readjust the brightness for good blacks and dark greys. Finally, make a slight adjustment to the contrast control to obtain the best shade contrasts.

Some further adjustment of the picture may be necessary whenever there is an appreciable change in ambient lighting, for instance when a light is switched on or a curtain drawn. Some receivers now fit an automatic contrast control using a light-dependent resistor mounted on the cabinet and connected in the A.G.C. line.

The fine tuner control should be adjusted for maximum sound consistent with good picture definition. An incorrectly adjusted control may cause sound-on-vision or vision-on-sound and will degrade picture quality.

B.B.C. Test Card " C "

A special test pattern is included in the morning television transmissions on weekdays, and this has been designed to give an immediate indication of the performance of the whole transmitting and receiving chain. As the performance of the trans-

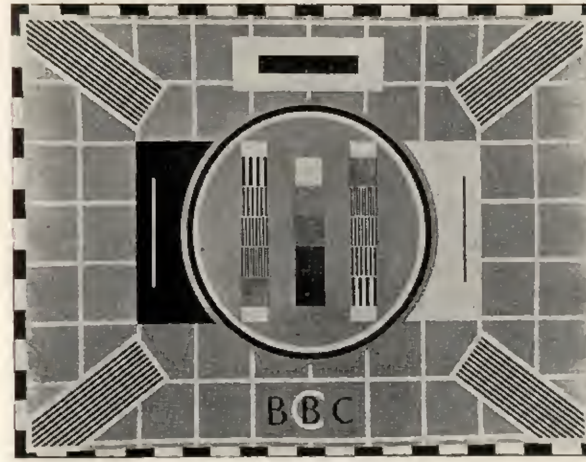


FIG. 2.—B.B.C. TEST CARD " C ".
(*Courtesy B.B.C.*)

mitting equipment is maintained in accordance with the agreed standards during the normal periods of radiation for test purposes, this Test Card " C " can serve as a check on propagation and the performance of the receiving apparatus.

The card, which bears the identification letter " C ", incorporates a number of patterns, each designed to assess one particular characteristic of the system, thus:

Aspect Ratio.—Concentric black and white circles surrounding the five frequency gratings will appear truly circular when the width and height of the picture are adjusted to the standard aspect ratio of 4 : 3.

Resolution and Band-width.—Within the circles there are two groups of frequency gratings, each consisting of five gratings having black and white strips corresponding to fundamental frequencies of 1·0, 1·5, 2·0, 2·5 and 3·0 Mc/s. In the left-hand group the 1·0-Mc/s grating is at the top, the frequency increasing towards the bottom, and in the right-hand group the order is reversed. The response of the whole system is required to be uniform to 2·7 Mc/s, so that the 2·5-Mc/s grating should be clearly reproduced, but the 3-Mc/s gratings may be blurred. The picture must just fill the viewing aperture during the test, with the black-and-white border visible.

Contrast.—A five-step contrast wedge appears in the centre of the test card. The top square is white, corresponding to 100 per cent modulation, and the lowest square is black, corres-

ponding to 30 per cent modulation. The three intermediate squares should be reproduced as pale, middle and dark grey.

Scanning Linearity.—The background of the test card is a middle grey, bearing a graticule of white lines. The areas enclosed between the lines should be reproduced in all parts of the picture as equal squares.

Synchronisation Separation.—The border consists of alternate black and white rectangles which facilitate recognising interference between the picture signals and the synchronisation.

Low-frequency Response.—A black rectangle within a white rectangle is provided, and in a perfect system it would be reproduced as a rectangle of uniform blackness on a clean white background. At present imperfections in the transmitting system result in a slight streaking at the right-hand side of the black area, even with a perfect receiver, but by experience it is possible to judge whether the reproduction is abnormal.

Reflections.—Reflections, which may occur in propagation or in the receiving installations, are indicated by two single vertical bars, which should be reproduced without positive or negative images at their right-hand sides. The width of these bars represents a pulse of 0·25 microseconds.

Uniformity of Focus.—There are four diagonally disposed areas of black and white stripes corresponding to a fundamental frequency of about 1 Mc/s, and all four should be resolved uniformly throughout.

The Test Card " C " radiated by the I.T.A. stations is the same except for the identification letters.

SERVICING PRECAUTIONS

In order to protect the public from the dangers of mains-connected chassis, a number of recommendations have been drawn up by the British Standards Institution (B.S. No. 415). The most important sections of the B.S.I. are in regard to the measures to be adopted to prevent the user from having access to " live " parts of the apparatus. Whether or not any particular part is " accessible " is to be determined by consideration of a " standard finger " consisting of a metal probe about the size and shape of the little finger of a human hand.

Points which are listed as normally requiring protection in receivers using A.C./D.C. technique include :

(a) *The Chassis.* The ventilation holes in the back-plate should be small enough to prevent access, and the back-plate itself should be removable only by means of a tool such as a screw-driver.

(b) *Control Spindles.* These should be either of insulating material or isolated from the chassis. Live spindles are considered to be acceptable only if the fixing holes for grub screws are subsequently filled with insulating material.

(c) *Fixing Screws.* All screws securing such parts as the chassis, loudspeaker, etc., should be isolated from the chassis. It is good practice to earth other large metal parts, including metal ornaments on the cabinet.

(d) *Chassis Outlets.* All outlets from the chassis, such as aerial and earth terminals, should be isolated from the chassis.

It is also recommended that apparatus should be tested for insulation by the application of a test voltage between the live parts and the safety earth provided.

General Precautions

(1) The chassis of almost all modern receivers are connected to one side of the mains supplies, and may therefore be " live ".

(2) Never attempt to measure the voltage at the anode of a line output valve directly, as the E.H.T. pulses will damage the meter.

(3) Before removing the picture tube make certain that the E.H.T. condenser is discharged: remember that Aquadag coating may hold its charge for long periods.

(4) Removal of a scanning-coil connection plug while the receiver is operating may cause picture-tube screen burn.

Mains-connected Chassis

In normal circumstances the risk of shock is no more pronounced with mains-connected chassis-type television receivers than it would be with broadcast receivers using similar arrangements. However, it should be noted that in the case of the television receiver, certain routine adjustments such as centring the picture, permanent-magnet focusing, etc., can be carried out only with the protective back removed from the receiver. While it is possible to check that the chassis is not above earth potential by means of a neon bulb or other simple type of tester, reversing the mains plug in its socket where necessary, a safer method in the busy servicing department is always to feed the receiver from an isolating transformer, having a low leakage inductance. This is not always possible, however, see page 129.

The service engineer should ensure that during servicing no alterations are made to a receiver that might invalidate the manufacturer's safety precautions, and should bring to the notice of the owner any deficiencies in receivers which do not fully comply with modern practice.

E.H.T. Voltages

Where receivers incorporate E.H.T. mains-transformer windings, extreme care should be exercised when servicing, as a shock from such a power supply may be lethal. Whilst other forms of E.H.T. such as line-flyback, R.F. or pulse oscillators, are less dangerous, serious burns and shocks are still possible, and due respect should be paid to all points at E.H.T. The engineer should also be on the look-out for cases where an open circuit in the E.H.T. bleeder chain results in the E.H.T. smoothing condensers being left in a charged condition, with the resulting risk of bad shocks.

SERVICING PRINTED-CIRCUIT RECEIVERS

Television receivers in which much of the wiring is in the form of printed-circuit panels were introduced in 1956 and have since become commonplace. This trend seems likely to continue because of the economic advantages to the manufacturer in reducing labour costs by the elimination of hand wiring and soldering, the ability to reproduce compact units having uniform performance and the saving of material.

Several different techniques of circuit printing are in use or under development. Components, of an orthodox design except for special soldering tags, are mounted on one side of a special panel of laminated plastic material with the main circuit wiring "printed" on the backing side. A thin layer of copper foil is bonded on to the wiring side of the panel. The complete "circuit" is then printed in an acid-resistant ink on to this copper foil. Those parts of the foil which are not protected by the ink are then etched away in an acid bath, leaving the foil to act as wiring between the required points: this technique is basically similar to that used in the production of printing blocks for book illustration. Holes are punched in the panel and the components are mounted on the insulated side with their connecting tags or wire ends protruding through the panel. The circuit side of the panel is then usually dipped into a bath of solder so that all components are soldered into the circuit in a single operation. The wiring panel is usually coated with a protective coating. More elaborate forms, with copper foil on both sides of the laminated panel, or with coils printed directly as spirals (as usual in television cross-over filters) or with some components such as valve-holders on the wiring side of the panel, may also be found, but the principle remains much the same.

From the servicing viewpoint the introduction of the printed circuit may be regarded as a mixed blessing. For instance, one advantage is that the component identification "R" and "C" numbers can be printed alongside the actual component for rapid identification, and with such sets all components are usually readily accessible without having to dig down through several layers of resistors and wires. On the other hand, tracing out an unknown circuit can be more difficult, even though the panels are often translucent so that the position of components can be observed when looking at the wiring side by bringing a 60-watt electric lamp close to the component side of the panel.

The main difference in the servicing of printed-circuit receivers is in the replacement of faulty components, calling as it does for greater skill and care in soldering. Too large or too hot a soldering-iron may cause blistering and damage to the laminated board. Very sparing use of solder is also necessary, as otherwise it may run between adjacent copper "wires" and be difficult to clear.

Tools

The following tools and aids are recommended:

(1) A low-wattage soldering-iron with a small point or wedge bit. The ratings should be less than 50 watts, and preferably less than 35 watts.

(2) Supply of 60/40 resin-cored solder.

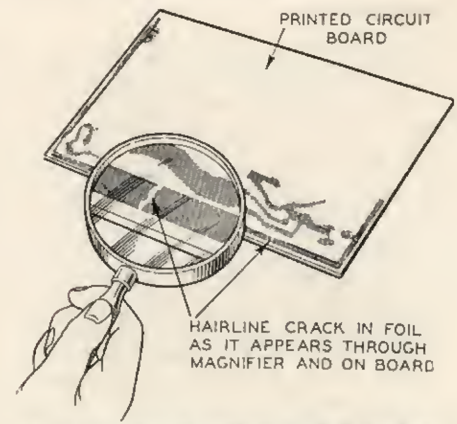


Fig. 3.—Using a Magnifying Glass to Examine Printed Wiring for Hair-line Cracks.

(3) Soft wire brush (such as suede-shoe brush).
(4) Pair of diagonal wire cutters.
(5) Pair of long-nosed pliers.
(6) Small wire pick or soldering aid.
(7) Needle-point probe for circuit testing.
(8) Magnifying glass for detection of small cracks.

General Precautions

(1) Avoid damaging the copper foil. Be careful when removing components not to cause small breaks in the foil. Should a small break occur, this can usually be "jumped" with molten solder, larger breaks should be repaired with single-strand connecting wire.

(2) Never apply excessive pressure to the wiring board, this can easily cause cracks or breaks in the foil.

(3) Excessive heating from large soldering-irons or due to overlong application of a hot iron may cause the bond between the board and the copper foil to break or blister.

(4) When replacing components avoid large deposits of solder.

These can easily cause a short-circuit or intermittent fault by bridging adjacent copper foils.

(5) When brushing off molten solder small particles may be left sticking to the board. Before installing a new component remove these particles with a cloth dipped in solvent.

Replacing Components

It is best to clean and tip with solder any new components before inserting them through the holes in the laminated base. The wired ends of resistors and condensers should be carefully trimmed and bent over so that when soldered into position there is no tendency for the component to force the copper foil away from the base. A method of overcoming this with simpler and non-critical circuits is to clip away the defective component with wire cutters, leaving as much as possible of the original connecting leads in place and then to shape the leads of the replacement component into small loops which can be slipped over the original leads and soldered into place; if the original leads are very short it may prove advisable to cut the old component in half with wire cutters and then strip the component away from its internal leads to provide slightly longer connecting wires. It should be noted, however, that when components are changed in more critical circuits, such as where parasitic or spurious oscillation is liable to occur with a change of stray capacitance or slight change in position of a component, this method of clipping off the lead and soldering the new component to the wire ends can result in instability. In such circuits it is better to remove the old component completely and to solder the new component in its place. In all cases where it is necessary to unsolder wires and lugs on the wiring side of the board, the following procedure should be used:

(1) Heat the connection on the foil side of the panel with a small soldering-iron. When the solder becomes molten brush it away with a soft wire brush, taking care not to overheat the connection, and removing the iron while brushing away the solder. It may require several sequences of heating and brushing to remove all the solder.

(2) Insert the blade of a knife between the copper foil and the bent-over component lead and bend the latter perpendicular to the board. It will sometimes be necessary to apply the iron to the joint while doing this where the connection has not been broken by the brushing.

(3) While applying the iron to the joint, gently "wiggle" the component until it comes away from the panel.

(4) Remove any small particles of solder which may be sticking to the protective coating of the circuit board.

(5) If there is a thin layer of solder left over the hole pierce this with the new component wires after heating the solder.

(6) Place the new component in position and cut the con-

necting leads as necessary. Bend over the ends against the copper foil and resolder the joint.

(7) Finally, recoat the affected area with a protective coating such as polystyrene dope.

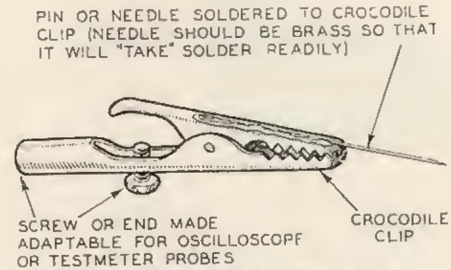


Fig. 4.—Construction of a Needle-point Probe for Testing Printed Wiring Panels.

Resistance and component measurements are usually possible from the component side of the board, but should it be necessary to work on the wiring side, it should be remembered that the protective coating over the foil forms an insulator; this can easily be penetrated by using a probe consisting of a brass needle soldered to a crocodile clip, see Fig. 4.

Fig. 5.—Printed Circuit R/C Bridge Kit.

[SECTION 9]

SERVICING EQUIPMENT

by F. LIVINGSTON HOGG, M.Brit.I.R.E., A.M.I.E.E.

FOR many years after broadcasting commenced, receiver servicing was carried out in many repair shops with extremely limited test gear. In fact, until the superheterodyne receiver compelled the use of a signal generator, far too often the attainment of a broadcast signal at reasonable volume, etc., was considered sufficient, and no other standards were attempted. Even now, a skilled engineer can do marvels on a sound receiver with a universal meter and a screw-driver. But in television this position never existed. Now all dealers have learned that some good test equipment enables far more and better work to be done on sound sets, yet some are still trying to start on television servicing in the bad old way.

A television receiver is not only far more complex, but it is quite impossible to line up most modern sets properly without test gear of a fairly comprehensive nature. This lesson is a hard one to learn, but no one should attempt television servicing work without a certain reasonable minimum. What this should be is a matter for argument, and the writer proposes to give his own personal views with which, doubtless, many experienced

FIG. 1.—AVO SIGNAL GENERATOR TYPE III.

This wide-range signal generator provides an R.F. output covering 150 kc/s to 220 Mc/s in six ranges. The dial is directly calibrated, and the output may be either modulated (1,000 c/s) or unmodulated. An audio frequency output at 1,000 c/s is also available. R.F. signal output is at 80-ohms impedance via a continuously variable attenuator and four-step decade multiplier.

(*Avo, Ltd.*)

FIG. 2.—TELEVISION WAVEFORM AND ALIGNMENT GENERATOR, 4-220 Mc/s.

This Instrument—Model 91A—Incorporates a pattern transmitter which provides a correct television waveform together with an a.m./f.m./c.w. generator, sweep alignment generator and fixed frequency audio signal generator.

(*Taylor Electrical Instruments Ltd.*)

engineers would disagree, in minor particulars, or in emphasis, in one direction or the other. However, on fundamentals there is fortunately no room for argument.

Most dealers graduate to television servicing via sound receivers, and therefore have some equipment already. When asked for a "priority list" in purchasing gear for television, neglecting any such items already available, the writer's list would be :

Absolutely Essential

1. Signal generator.
2. Universal meter, 20,000 ohms per volt.
3. Pattern generator, giving a true B.B.C./I.T.A. pattern.

Very Desirable

4. Oscilloscope.
5. Wobbulator.
6. Insulation Tester.
7. Component Test Bridge.

Well Worth While

8. Valve Tester.
9. E.H.T. Voltmeter.
10. Signal-strength Meter.
11. Valve Voltohmmeter.
12. Crystal Calibrator.

This list is not exhaustive but is only a guide.

When investing in test gear, it must always be borne in mind that the criterion is that the equipment should earn its keep. On the other hand, equipment unintelligently used will never pay. To be satisfactory, the gear must be reliable and always give the same reading in similar circumstances. It must be reasonably easy to handle, so that it does not mislead. Nevertheless, unless test gear is handled and used wisely it can be a time waster. Hours can be spent on the niceties of alignment, which, although they may appear to have considerable influence on the measured responses, hardly alter picture quality one iota. A good engineer is made efficient and productive by good test gear, but good test gear will not make a bad engineer into a good one. But, what is more important, a trainee engineer,

FIG. 3.—THE "TELEVET" TYPE 259, A PORTABLE MULTI-PURPOSE TELEVISION TEST INSTRUMENT.

This instrument contains in one unit 15½ in. × 9½ in. × 8½ in. a wobbulator (sweep up to 12 Mc/s and provision for crystal setting); an amplitude-modulated signal generator (two ranges 8–70 Mc/s and 168–230 Mc/s, with 5-Mc/s crystal check calibrator; a pattern generator providing a pattern consisting of three horizontal black bars on three vertical black bars; an audio test signal (5 kc/s); an oscilloscope with built-in Y amplifier and time-base; an E.H.T. voltmeter; an A.C./D.C. valve voltmeter; and an *in situ* line output transformer tester.

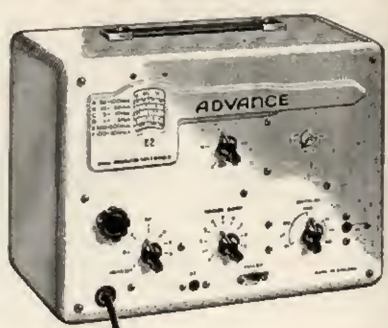
trained to use good equipment properly, has a better chance of becoming an efficient engineer than if he has little gear and has to acquire more instinctive skill before he can show results.

There are many manufacturers of test gear, and their products

FIG. 4.—SIGNAL GENERATOR TYPE E.2.

The frequency range is 100 kc/s to 100 Mc/s on fundamentals. Internal modulation at 400 c/s 30 per cent is available, and it may be modulated from an external source. The R.F. output is continuously variable from 1 μV to 100 mV, and a constant output of approximately 1 V at 50 ohms impedance is also available. For Band III work, an alternative model, type 62, has been introduced with a range of 150 kc/s to 220 Mc/s.

(*Advance Components Ltd.*)



range, as for every other commodity, from good to bad. It would be possible to make a fairly comprehensive list of all available apparatus which would be only a catalogue, of little help to the engineer. The writer therefore proposes to outline the desirable features of the various types of instrument mentioned above, and then to give a few selected examples from recent production. These examples are those he has used and knows to be satisfactory, but many other satisfactory instruments are not mentioned. There are also others. . . . It is not proposed to discuss those instruments which are mainly used in development laboratories, but to consider only instruments of types normally supplied for servicemen's use.

Signal Generators

At one time these could be divided into two classes, more aptly named test oscillators and standard signal generators. The former consists of a tunable oscillator, which can be modulated, together with means of attenuating the R.F. output. The second class has all these features, but also has a means of setting the output level to a known and repeatable value on all frequencies. The test-oscillator output varies, perhaps widely, with frequency, rendering comparative tests sometimes quite misleading. Years ago the difference in performance was very great, but clever design has produced most efficient test oscillators with remarkably constant output which enables quite good relative checks to be made. It is necessary to stress that the signal generator *must* tune to the fundamental television frequencies. In the writer's opinion the suggestion of using harmonics is a diabolical one designed to mislead the unskilled and unwary!

It would be preferable if service stations used metered signal generators exclusively, but the modern cheaper variety is so good, in its best examples, that cost often overrides. It is, however, suggested that all service stations should have at least one standard metered generator to serve as a check against deterioration of standards of performance.

One essential feature of a signal source is good frequency stability and resetting accuracy. Unfortunately the requirements of television sets working on single sideband are very high, in fact higher than can be reasonably expected from the most expensive laboratory generator. No tunable oscillator of normal type can be expected to hold over a long period to as good as 0·1 per cent, including resetting accuracy, and few manufacturers guarantee better than 1 per cent. The variation of stability of the television set will absorb most of the tolerance available, therefore the source stability should be much better so that the error from it is negligible. This means that it should be certainly within 20–30 kc/s of nominal, which is round 0·03–0·04 per cent.

Clearly if we demand such stability from our signal generators we shall either delude ourselves or be disappointed.

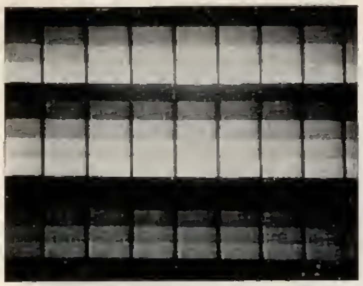


FIG. 5.—TELEQUIPMENT WG/44 PATTERN.

This photograph shows non-linearity and ringing. The number of vertical lines is adjustable from about 5–20.

The simplest way of overcoming this is to beat the carrier of the signal generator with the station, so synchronising them, and noting how much the generator deviates and how it drifts during working periods. A little experience soon shows how frequently this must be done, and how closely the required channel can be set up without reference to the station. This is not an ideal method, and sometimes it is not possible to use it. The ideal method is a crystal calibrated wavemeter or oscillator, which will be considered later.

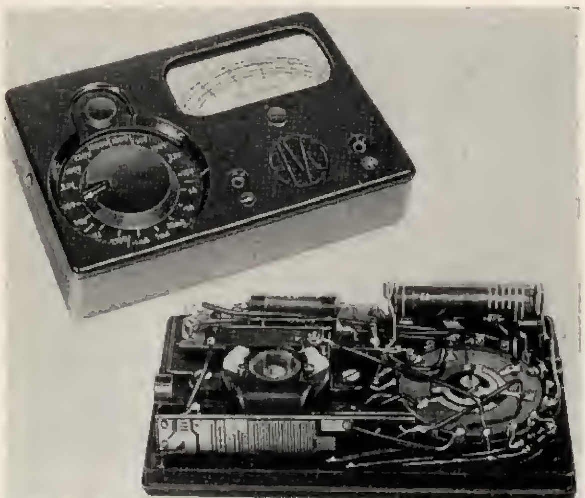


FIG. 6.—THE "MULTIMINOR" MULTI-RANGE TEST METER.

The internal construction, using printed circuitry, is shown in the lower right-hand portion of the illustration. Sensitivity is 10,000 ohms/volt on D.C. ranges.
(*Avo, Ltd.*)

Universal Meters

The ubiquitous Avometer here comes to mind, although there are other good instruments available. For television work it is often essential to have a high-resistance meter of 20,000 ohms per volt, such as the Avo Model 8. However, some manufacturers' service data still calls for a 1,000-ohms per volt meter such as the Avo Model 7, so that it is normally necessary to have both types at hand.

In choosing an instrument it is very important to be sure that good overload protection is incorporated. The extra cost is saved in every shop sooner or later.

Pattern Generators

A television pattern generator should be used not only when the actual transmissions are not on the air, but at all times. The real picture content is continually varying, and is sometimes of variable quality. It is also subject to interference. A constant pattern is far more satisfactory for servicing, and is not misleading (or even interesting ! At test match times . . .). The statement that of course the final criterion is what the actual transmission looks like, is not as all embracing as might appear.

This assumes that the pattern generator and the actual transmission have equal effect on the receiver as to synchronising, etc.

FIG. 7.—"AVO" UNIVERSAL TEST METER.
(*Avo, Ltd.*)

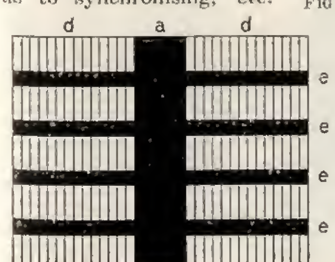


FIG. 8.—MURPHY TPG.11 PATTERN.

(*a*) 20,250-c/s master oscillator central vertical bar and line blanking pulse.
(*d*) 300-kc/s vertical grey bars.
(*e*) 250-c/s horizontal black bars and frame frequency blanking pulse.

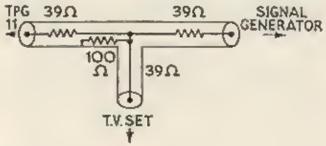


FIG. 9.—T-PAD FOR MIXING SIGNAL GENERATOR OUTPUTS.

Now the picture waveform is extremely complex, and this complexity is necessary. A television pattern generator must therefore give a fully synchronised interlaced pattern having all the characteristics of the real transmission. A receiver adjusted on such a pattern generator will then immediately give a correct picture on the station, provided that the correct R.F. level is used. This applies to all phases of servicing adjustments—linearity, aspect ratio, interlace, hum level, sound on vision, etc. All can be checked with a good pattern generator with certainty that all will be well when the station comes on.

But if the pattern generator does not give exactly the correct waveform; if it does not incorporate interlace, or have line and frame frequencies derived from a single oscillator, or half-line pulses, or the front and back porches, or any such feature, it is useless and should not be admitted to the service station. The reason for this drastic statement is that such an instrument

FIG. 10.—MODEL 1052 DOUBLE-BEAM OSCILLOGRAPH.

A general-purpose instrument providing two identical amplifying channels with a maximum gain of 2,000 and an upper frequency response of 3 Mc/s. The repetitive or triggered time-base has a sweep duration from 200 milliseconds to 5 microseconds. The instrument will operate from power supplies of the various frequencies and voltages encountered in the Armed Services or from standard civil supply mains.

(*Cossor Instruments, Ltd.*)

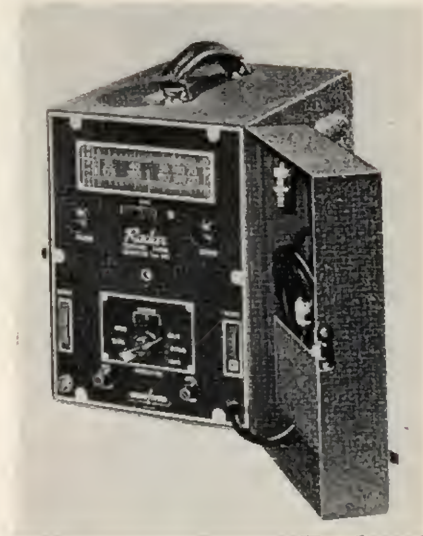


FIG. 10 (*a*).—RADAR TYPE 405 TELEVISION SIGNAL GENERATOR.

A complete range of patterns, together with correct sync. pulses, is provided. Simultaneous sound and vision R.F. signals, are given, the ranges being 40–70 Mc/s and 174–216 Mc/s.

(*Waveforms, Ltd.*)

gives misleading results, which must be avoided at all costs. On such a pattern generator any adjustment made cannot be guaranteed correct for the actual transmission—it may look right on the pattern generator and be wrong on transmission, or vice versa. Some receivers will in fact only function properly when fed with an interlaced pattern.

The writer makes no apology or attempt to conceal the bee in his bonnet on this matter. He considers that no one should have the temerity to attempt television servicing commercially without a pattern generator, and, furthermore, that any pattern generator not conforming fully to B.B.C. standards should not be allowed on the premises!

It may be mentioned at this juncture that the optimum pattern generator for use on sets with flywheel synchronisation is not the optimum for sets without this facility. In order to cope with both cases a compromise has to be adopted, which leaves so little to be desired that most would be unaware of the deficiency.

Oscilloscopes

There is much difference of opinion over oscilloscopes, some finding them of inestimable value, and others not. Probably the reason for this lies partly in the handling, and in knowing how to interpret the results. If the 'scope amplifiers have a reasonably high gain, and the input of the 'scope is connected to a high-impedance circuit, the resulting trace may be modified

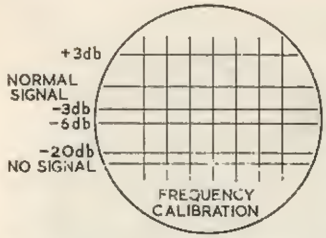


Fig. 11.—Typical Graticule Layout.

or completely upset by spurious pick-up, mains hum, etc. The attachment of the 'scope input may also disturb the operation of the circuit under test. Only experience can show how to overcome these difficulties in different cases. In the writer's opinion the greatest value of a 'scope is in conjunction with a wobbulator.

Some points to look for in choosing a 'scope are: good sensitivity variable over a wide range, wide frequency range and a good linear time-base. For many purposes a good H.F. response is unnecessary, but it is invaluable when checking a pattern generator, or when looking for spurious H.F. oscillations on L.F. circuits.

Several useful instruments are made by Cossor. Their Model 1039M is extremely small and light. It has a 2¾-in. single-beam tube, but because of its small size, the L.F. and H.F. response is limited. Model 1035 is a much larger instrument having a 4-in. double-beam tube, with calibrated time and voltage scales and many other facilities. The Telequipment Model 520 is remarkably light considering its 4-in. single-beam tube. It is notable for its wide H.F. response, covering the whole face of the tube. These two last instruments are particularly convenient for viewing waveforms from pattern generators.

Wobbulators

A wobbulator, or frequency modulated oscillator, together with an oscilloscope, is undoubtedly far the best apparatus for lining up television sets to the correct band-width accurately and quickly. As usual, however, there are snags. The apparatus

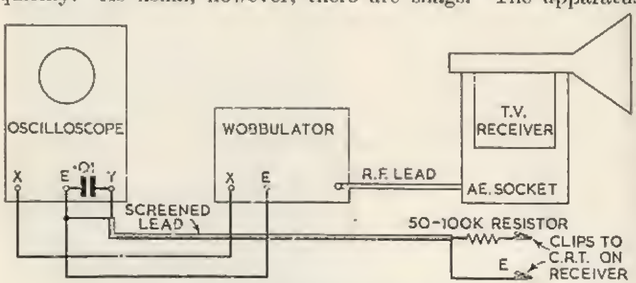


Fig. 12.—Wobbulator Connections.

N.B.—Series earth condensers to be fitted where necessary.

Fig. 13.—(*above*) Taylor 20,000 ohms/volt Pocket Testmeter and (*right*) Q-scan Oscilloscope for Television Receiver Alignment by Marconi Instruments.

must be right, it must be connected appropriately and must be used correctly. Matters have not been helped in that makers' instruction books have not emphasised the pitfalls sufficiently.

In the first place, optimum alignment should be made at the working sensitivity of the receiver, or at a lower input signal. As most reasonably priced wobbulators are not fitted with accurate attenuators, this sometimes leads to trouble. Secondly, the oscilloscope must be connected in such a way as not to affect the operation of the receiver. Practically, the output is normally taken from grid or cathode of the cathode-ray tube. If a clip is fitted to a resistor of 50,000 ohms upwards, which is connected in series with the conductor of a screened cable, with a further clip from the screening for earthing, this can be connected to the 'scope and will not usually upset the receiver at all. If it does, slight readjustment of leads or resistance should remove the trouble. Next factor of importance is the sweep frequency. This must be low; 16⅔ c/s (⅓ mains frequency) is good, 25 c/s should be the maximum. This is on the limit of a small oscilloscope (and some larger ones), which distorts the waveform if the frequency is too low for it. It is also good to connect a condenser of about 0·01 μF across the input to the 'scope amplifier.

The method of operation of a wobbulator differs somewhat with different sets. Usually if the set is not far from alignment, injection into the aerial or at I.F., and alignment in order working

FIG. 14.—COSSOR "TELE-CHECK".

Correctly tuned vision response curve taken from a typical single sideband receiver. The marker pip is at vision carrier frequency.

from the circuits nearest the 2nd detector through finally to the aerial, is the drill. Sometimes it is necessary to inject into each grid in turn, dealing only with the immediately subsequent circuits in turn, arriving finally at the aerial end. Each type of receiver has its own idiosyncrasies, but experience is the only way to find the optimum method in any particular case. It is a good thing to make a graticule showing the calibration of the instrument in frequency in the horizontal (X) direction and calibrated in db in the vertical (Y) direction, say at 3 db up, 3 db, 6 db and 20 db down on the normal deflection (3 db down is 70 per cent, 6 db down is 50 per cent, 20 db down is 20 per cent of normal, but 3 db up is 140 per cent). Here is a wonderful opportunity for time-wasting, trying to get a perfect curve. It must be remembered that getting the carrier at the 3-db or 6-db point is important on a single-sideband set, but that dips or rises of 2 or 3 db over the band will hardly affect the picture. As long as the carrier is right and the band-width adequate small irregularities are of no consequence.

Another important thing is the frequency setting of the wobbulator. If a signal from the generator is injected into the wobbulator (if provided with a suitable terminal) or through a T-pad with the wobbulator, a kink will be seen on the trace at the frequency corresponding to the generator frequency. The 0·01-μF condenser across the 'scope will prevent the high-frequency beats from widening the trace, and enable an accurate adjustment to be made. Care must be taken that the signal-generator signal is not too strong, or it may modify the trace

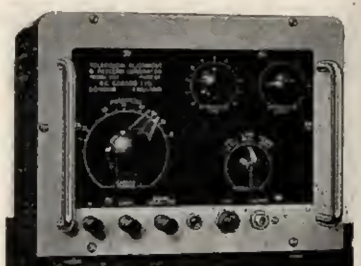


FIG. 15.—"TELE-CHECK" MODEL 1320.

Alignment is carried out by using the instrument in conjunction with an oscilloscope. The frequency modulation sweep is 7 Mc/s, and the carrier frequency is 7–70 Mc/s. Provision is made for the injection of a frequency marker pip from a signal generator. Other models are available having a sweep of 10 Mc/s and covering both Band I and Band III.

(*Cossor Instruments, Ltd.*)

FIG. 16.—COSSOR "TELE-CHECK"

A double-beam tube employed for the observation of both the sound and vision response curves of a single sideband receiver simultaneously. The sound channel is incorrectly aligned in this instance.

from the receiver, and so mislead. A better method is to feed from the T-pad into a crystal rectifier with a load of say 10,000 ohms in series. The 'scope (with 0·01-μF condenser) is then connected across this 10,000-ohm resistor. The marker can then be used to check the linearity of sweep and calibrate a graticule.

A wobbulator correctly used often shortens alignment time to between one-tenth and one-fifth of the time taken by ordinary methods, including dampers, etc. The technique of using it is, however, of vital importance.

Two commercial wobbulators are the Cossor Telecheck and the Marconi Instruments' "Q" Scan.

The Telecheck covers 7–70 Mc/s, and is frequency modulated $\pm 3{\cdot}5$ Mc/s by the time-base voltage from the oscilloscope used for viewing. On Cossor oscilloscopes there is a terminal from which this voltage (100 V or so) can be obtained. When using other makes of oscilloscope care must be taken that suitable connections are made. For instance, when using a 'scope with a push–pull amplified time-base, such as the Telequipment Model 520, the voltage input to the amplifier is too low for satisfactory use. The necessary voltage is available on the plate plug at the rear of the instrument, and

FIG. 17.—MODEL 130B INSULATION TESTER.

A mains operated ohmmeter for workshop tests and component checking. Measures up to 1000 MΩ at a test pressure of 500 volts.

(*Taylor Electrical Instruments Ltd.*)

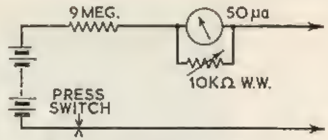


FIG. 18.—INSULATION TESTER.

Calibration of meter:

Current (μA) .	50	45	40·9	32·1	28·1	23·6	18·8	15·5	7·6	4·1	2·1	0
Resistance (MΩ) .	0	1	2	5	7	10	15	20	50	100	200	∞

should be taken, through a blocking condenser 0·25–2 μF, to the Telecheck.

The Marconi "Q" Scan incorporates the necessary oscilloscope, which can be used independently if desired. The frequency range is 10–95 Mc/s, and the maximum sweep is 5 Mc/s total, which is ideal for single-sideband receivers.

A very comprehensive survey of wobbulator techniques with special reference to the Telecheck was made by W. I. Flack in an article in *Electrical & Radio Trading*, July 1953, reprints of which are available on request from Messrs. A. C. Cossor Ltd.

Insulation Testers

A large proportion of faulty components in television receivers have faulty insulation, and the writer believes that much inferior performance can be attributed to leaky condensers in particular. In the writer's laboratory all such components are tested on 500 V D.C., with quite startling results. For such tests an instrument giving a maximum reading of 200 megohms is the minimum requirement, but high accuracy is not needed. The Wee Megger needs no introduction, and particularly when extreme portability is required, such types with hand-driven D.C. generators have no rivals. A very convenient mains-operated device is the Taylor Model 130B, which derives the 500-volt supply from the mains. It is also possible to make a very simple instrument using eight 67½-V deaf-aid-type batteries, a few resistors and a 50-μA meter. The battery drain never exceeds about 50 μA, and the life is extremely long; some have been in use for seven years before running down.

Component Test Bridges

Many faults arise due to components, mainly condensers and resistances, changing in value. These are best checked on a bridge. The requirements are that the full probable range of values of capacity and resistance can be measured reasonably accurately, say to within 5 per cent at worst. Even this is a fairly stringent requirement. It is sometimes an advantage to have the facility to measure inductance as well, but for a number of reasons this facility is not as useful as it would appear.

Three good instruments, each with their own special features,

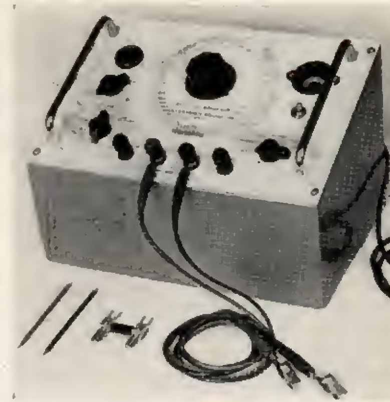


FIG. 19.—CAPACITOR ANALYSER AND RESISTANCE BRIDGE, TYPE CRB3.

This test bridge covers ranges 20 pF to 500 μF; 50 ohms to 100 Megohms. It measures capacitance by means of a Wien bridge; the resistance of all types of carbon and wire-wound resistors; the leakage resistance of paper and electrolytic capacitors and all types of insulation, 25–500 V, by flashing neon. It directly indicates leaky, shorted, low-capacity, high-capacity and high-power-factor capacitors of both usual and intermittent types. Measurements are made directly, and no calculations are necessary.

(*A. H. Hunt (Capacitors) Ltd.*)

are the E.M.I. QD.211 Component Bridge, the Avo Universal Test Bridge, and the Hunt Resistance and Capacity Bridge.

Valve Testers

A valve tester can be a great help, but it must be borne in mind that it is no reflection on the instrument that it will undoubtedly fail to reveal some valve faults. If it were not for this, a valve tester would rate higher in the priority list. The writer personally prefers a valve characteristic meter, which enables values to be measured on a meter, which is perhaps an understandable bias!

E.H.T. Voltmeters

The measurement of E.H.T. Voltages is a very difficult problem. Very little current is available for a meter, and leakage

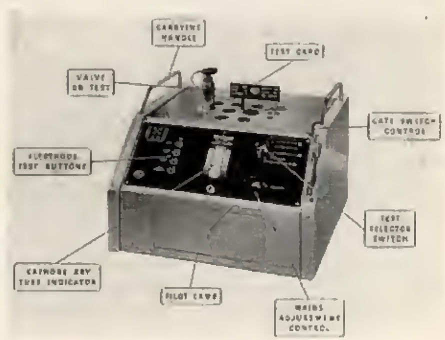


FIG. 20.—HIGH-SPEED ELECTRONIC VALVE TESTER.

All electrode potentials are automatically applied by the insertion of the appropriate perforated test card in a multiple gate switch. The tests include: filament or heater continuity; electrode insulation with and without H.T. applied; heater-cathode insulation; grid current; emission.

(*Mullard Ltd.*)

FIG. 21.—SCALAMP ELECTROSTATIC VOLTMETER.

Available in three ranges: 1–5 kV A.C., D.C., 3–10 kV A.C., D.C., and 5–18 kV D.C. or 5–10 kV A.C. A direct-reading instrument with a 3-sec. period. The lamp can be operated from A.C. mains or 4-V battery.

(*W. G. Pye & Co. Ltd.*

due to humidity is a particular snag. Two methods, which can be satisfactory, are to use an electrostatic meter, or a very low current (20–25 μA) meter with high series resistance. Both methods are unfortunately costly. Some results can be obtained by connecting say three 5-kVA electrostatic meters in series, and summing the readings, but great circumspection is required.

The Pye Scalamp E.S.V. is ideal for this purpose. Other methods than the above have been proposed, but, for reasons such as are given above, cannot be commended.

Signal-strength Meters

Such a device as a signal-strength meter is valuable in two main connections. Firstly, in assessing strength of signal at new locations, and secondly, in testing existing aerial installations. It is important to make such measurements not on picture content, but on peak white or synchronising levels.

Valve Voltohmmeters and Crystal Calibrators

Valve voltohmmeters do approximately all that a Universal Test Meter will do, and much besides. Unfortunately they are fairly delicate and a shade tricky to handle. If such difficulties are appreciated, and care used in getting results, they are most useful adjuncts to any test shop. The uses are legion, but good engineering skill or supervision is needed. The lack of these and a failure to appreciate the limitations of technique have given this type of instrument a bad name not altogether deserved.

Good examples are: The Avo Electronic Test Meter covering 250 mV to 250 V D.C., 25 μA to 1 A D.C., 1–250 V A.C., and 16–16,000 ohms mid-scale resistance, and the Marconi Instruments' T.F.887A Valve Voltohmmeter, which has ranges of 5–250 V D.C., 5–125 V A.C. and 12·5–50,000 ohms mid-scale resistance.

As stated earlier under "Signal Generators" a crystal calibrator or wavemeter is a great help. Unfortunately the frequencies required are all awkward, except that of London, so that if one tries to use the harmonics of a single crystal it must be 0·25 Mc/s. This is too low for convenience. The only commercial instrument now available that the writer has come across is the

E.M.I. spot frequency marker AD/U405, which gives 1-Mc/s pips throughout the range. In some cases this is sufficient, but in others the dial of the signal generator cannot be read accurately enough. U.S. surplus wavemeters BC.221 or TE.149, if properly recalibrated and adjusted, can be used, or, particularly if only one channel is required, a simple crystal harmonic generator oscillator can be made up.

Conclusion

Instruments are not the only items of importance in a repair shop. The obvious ones of good bench space and so on need no stressing. But a point overlooked too often is that television sets are lethal. Every test position must be equipped in accordance with the Factory Acts and regulations.

An essential is a properly screened double-wound transformer of 1 to 1 ratio. The screen should be well earthed. An earth bar may be fitted at the back of the bench, but it must only be connected to earth through a series condenser of high test voltage and not more than 0·02 μF capacity. Where earth terminals of instruments would be connected effectively direct to the mains via a live chassis, isolating condensers of similar type are essential.

The whole load of the bench or test position, for one engineer only, should come from one transformer secondary, connected to a multiplicity of sockets of all likely types and sizes. Two engineers should never share a transformer—they could get two chassis not very far apart connected to opposite sides of the A.C. supply. This problem must be dealt with according to circumstances.

* * *

While the use of a double-wound isolating transformer having low leakage inductance has much to recommend it on the grounds of safety, it is unfortunate that some television-receiver fault symptoms and adjustments are affected by the use of such a transformer. For this reason it is often necessary to operate the receiver directly from the mains supply, and in such circumstances the best safeguard is to ensure—by checking with a neon bulb or similar tester of known reliability—that the chassis is always connected to the neutral and not the live mains lead, taking care to re-check each time that the mains lead is re-connected.

The introduction of kits using printed-circuit panels offers an economical method of building up a range of servicing instruments. The home construction of good test instruments has in the past been regarded as a most tricky operation owing to the likelihood of even minor differences of lay-out and construction leading to considerable variations in results and in calibration. In these new kits this difficulty is overcome by the use of printed-circuit panels giving a degree of consistency between instruments difficult to achieve by other means. These kits, including oscilloscopes, valve and multi-range testmeters, signal generators, etc., are supplied with step-by-step assembly instructions.

E

[SECTION 10]

RECEIVER AERIALS

THE requirements of an aerial system for television reception are considerably more exacting than those for normal broadcasting purposes. This is because of:

(1) the lower power, and correspondingly lower field strength of television stations;

(2) the greater band-width required, and consequent lower gain per stage in the receiver;

(3) the higher circuit and insulation losses, and greater valve noise on V.H.F.;

(4) the greater susceptibility of V.H.F. signals to electrical and ignition interference;

(5) the necessity to avoid receiving transmissions by multiple paths in order to reduce "ghost" images;

(6) the greater susceptibility of the eye, as compared with ear, to interference and signal variations.

On the other hand, it should be recognised that the use of a directional aerial system, tuned for optimum pick-up on a limited range of frequencies, and coupled to the receiver by a matched transmission line, represents basically a much more efficient type of arrangement than is customarily employed for broadcast reception.

The choice of an aerial and transmission line for any particular installation will depend upon the distance from the transmitter; its height and freedom from screening; the level of local interference; the length of feeder cable necessary; the sensitivity and input impedance of the receiver; and any restrictions imposed by the landlord or local authorities. It should be emphasised, however, that when planning an installation it is better to provide too much rather than too little signal input; for while it is a simple matter to incorporate an attenuator pad in the feeder to reduce an excessive signal, the raising of the signal level by even a few decibels may require the complete re-planning of the installation. Unlike valve amplification, additional gain in the aerial does not introduce "noise".

Aerial Terminology

Half-wave Dipole. The fundamental form of a resonant aerial is a single conductor with an electrical length equal to half the wavelength on which optimum reception is required.

Aerial Impedance. The natural impedance varies with the current distribution along the aerial. For a half-wave dipole the

impedance at the ends is several thousand ohms, and approximately 72 ohms at the centre. Additional director or reflector elements will tend to reduce the impedance, and on a four-element array the centre impedance may be of the order of 25 ohms.

Field Strength Pattern. The variation of reception around an aerial is normally shown graphically by means of "polar diagrams", which are circular charts with the angle (0–360°) indicating the direction for which the signal strength is plotted, and the length of the radial arm indicating its magnitude.

Aerial Gain. This term expresses the increase in signal strength for one type over another, a standard half-wave dipole usually being adopted for reference purposes. The gain is measured in the direction of optimum reception, and is usually expressed in decibels. Thus an aerial with a 6-db gain would provide double the voltage, or four times the power, across the input circuit of the receiver.

Front-to-back Ratio. This is the term used to denote the ratio between the pick-up, when the aerial is orientated for optimum response, to that for the position of minimum response. It is usually expressed in decibels.

Decibel (db). The one-tenth part of a bel, this latter being the common logarithm of the ratio between a second power, or intensity, and a first one. The decibel, therefore, is a unit for expressing the gain or loss in an electrical or acoustic circuit when the input is known, or of defining any power in relation to a predetermined basic level of that power.

The Dipole

This, the simplest form of tuned aerial, consists in practice of a metal rod, divided at its centre by an air gap of about 1 in. for connection of the transmission line, and of overall length approximately half that of the wavelength on which optimum reception is required. Owing to end effect, the length is not an exact half-wave. The formula below will enable the length to be determined:

$$\text{Length (in.)} = \frac{5905 \times k}{\text{Frequency (Mc/s)}}$$

where k is a factor depending upon the ratio of half-wavelength to the diameter of the aerial element, usually varying between 0·92 and 0·98. So as to ensure that the band-width of the aerial is sufficient, the length/diameter ratio should be less than 400. The impedance at the centre is approximately 72 ohms, but this may be affected by the presence of nearby objects or additional elements.

The signal being received produces a standing wave in the dipole, which results in there being zero current but maximum voltage at the extreme ends of the rod, and maximum current but low voltage at the centre. The signals are fed to the receiver via a feeder cable which in order to minimise loss must be fairly

TABLE 10.1.—TYPICAL DIMENSIONS OF TELEVISION AERIALS

Channel	*Mean Freq. (Mc/s)*	*Dipole* *ft.*	*in.*	*Director* *ft.*	*in.*	*Reflector* *ft.*	*in.*	*Spacing* $\frac{1}{4}\lambda$ * *ft.*	*in.*
1	43·5	10	7	10	1	11	1	5	6½
2	50	9	3	8	9½	9	8½	4	9
3	55	8	5	8	0	8	10	4	5
4	60	7	8½	7	4	8	1	4	0½
5	65	7	1	6	9	7	5	3	8½
6	178	2	7½	2	6	2	9	1	4½
7	183	2	6½	2	5	2	8	1	4
8	188	2	5½	2	4	2	7	1	3½
9	193	2	4½	2	3	2	6	1	3
10	198	2	3½	2	2½	2	5	1	2½
11	203	2	3	2	2	2	4½	1	2
12	208	2	2½	2	1½	2	4	1	2
13	213	2	2	2	1	2	3	1	1½

* Halve these dimensions for $\frac{1}{8}\lambda$ spacing.

Note The exact dimensions are affected by the ratio of diameter to overall length, and so will vary slightly according to the tubing used.

accurately matched in impedance to that existing at the point of connection to the aerial system, and also to the input circuit of the receiver. Where the co-axial type of feeder is employed, the centre conductor should be connected to the upper half of the rod and the outer conductor to the lower section.

The simple half-wave aerial is intended for use in areas where reception conditions are good; where interference is to be met with, its non-directional properties are against its use.

Dipole Plus Reflector: the H Type

By mounting another slightly longer metal rod at one-quarter or one-eighth of the signal wavelength behind the dipole, the aerial can be made directional. Typical dipole and reflector lengths are given in Table 10.1.

The spacing of the two rods is not critical; typical spacings are 5 ft. 6 in. London, and 4 ft. Birmingham. The spacing distance, however, will affect the dipole impedance and its polar diagram. The rod has no electrical connection with either the dipole or any other part of the aerial system.

The reflector increases the pick-up efficiency of the dipole in the forward direction (as a rule it is about 5 db better than the standard dipole) and reduces it in the rear, the front-to-back ratio being of the order of 9 db. Where interference radiation is strong and lies behind and not across the transmitted signal's path, effective screening can be achieved by putting the reflector between the interference source and the aerial proper. When this has been done, the aerial may no longer be "pointing" towards the transmitter, but this makes little difference, provided that the direction of the aerial is not more than 30° from the correct position.

From a signal-strength viewpoint, and also as regards interference free signals, the H type aerial should prove satisfactory in all but the most distant and difficult locations.

Directors

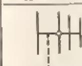
A director is an element of slightly less length than the dipole, and serves to increase the forward gain of the system. Director lengths can be determined by using the following formula:

$$\text{Length (in.)} = \frac{5400}{\text{Frequency (Mc/s)}}$$

X Aerials

This design represents modifications to the basic H type aerial, and offers certain advantages in ease of fixing, etc.

TABLE 10.2.—PROPERTIES OF VARIOUS TYPES OF BAND I TELEVISION AERIALS

TYPE OF AERIAL	RELATIVE GAIN TO A DIPOLE	POLAR DIAGRAM (RELATIVE)	PROBABLE MAXIMUM RANGE (MILES)	OCCASIONAL RANGE (MILES)
 DIPOLE	Odb (i.e. THERE IS NO GAIN. SIGNAL PICK UP IS x1)		18	50
 V DIPOLE	-6·Odb		14	35
 DIPOLE WITH REFLECTOR	4·O to 5·Odb		35	70
 ARRAY	7·O to 8·Odb		35+	70+

With the "Antex" design, the aerial rods radiate in this form from a single junction unit. One pair of rods constitutes a V dipole; the other pair, forming a V on the same plane, acts as a modified director. Maximum signal pick-up is obtained when the directors are pointed towards the transmitter. The manufacturers (Antiference Ltd.) claim that this aerial has a better performance than the H type, with less susceptibility to ignition-interference signals arriving from below the horizontal, and that it is easier to install.

Another variation is the Band I "Bi-Square" aerial intended primarily for long range loft installations as the overall size is of the order of 5½ ft. square. The manufacturers (Labgear Ltd) claim that good results can usually be achieved up to 40–50 miles from a main transmitter.

Folded Dipole

In this arrangement two half-wave aerials are connected at the ends and run parallel to one another, some ½ in. or so apart, one dipole being broken at the centre for connection to the transmission line. The polar diagram and gain are substantially the same as for a simple dipole, but the system has a broader band-width, while the impedance is approximately four times greater. These characteristics are of value for multi-element arrays in order to simplify matching to the feeder.

Multi-element Arrays

This type is intended mainly or use in fringe areas. It possesses a very high order of gain and directivity, together with a slightly reduced band-width, both of which improve the signal-to-noise ratio. The forward gain is about 8 db, and the front-to-back ratio about 20 db. The array is usually composed of one or more director elements, a dipole and a reflector.

Room Aerials

One result of the greater sensitivity of modern receivers is that telescopic and other simple room aerials are capable of providing reasonable results over quite large areas, although—particularly on Band III—pockets of poor signal strength are likely to be found even close to the transmitters. Many of these aerials are basically Band III dipoles which also provide a roughly equivalent signal from Band I stations whose signal strengths tend to be higher.

The best location for these aerials can be found only by trial and error; moving the aerial to find a place where there is minimum fading caused by people moving in the room (or beyond a party wall) and freedom from "ghost" images.

Loft Aerials

Special loft aerials are available which have directional properties. An example is the inverted V type, which possesses sharp minima at right angles to its plane, an advantage for the removal of "ghosts" or the elimination of local interference. It comprises two quarter-wave rods set at 45° to the vertical, each half of the V being connected to the feeder cable, thus making it independent of the angle of polarisation.

High-gain "bi-square" loft aerials (Labgear Ltd.) are also available for long-distance reception on Band I for use in locations where outdoor aerials would be difficult to erect.

Slot Aerials

This type of aerial may be used as an alternative to the simple dipole, or dipole and reflector, to which is has roughly similar performance. For installation in the loft of a house, it has the advantage that, for vertically polarised transmissions, it is

long rather than high. It consists of a vertical sheet of conducting material, such as wire netting, with a slot running horizontally in the centre and the feeder connected to the mid-points of the long sides of the slot. Typical dimensions for Channel 1 are: netting, 15 ft. long × 5 ft. high (these dimensions are not critical); slot 10 ft. long × 1 ft. high.

Skeleton Slot Aerials

A form of the slot aerial that is in common use for Band III reception is the "skeleton slot". As its name implies, this type of aerial was developed from the normal slot by gradually reducing the metal surround. It has been found that results substantially the same as those of the normal slot may be obtained even when the surround is reduced to a mere rim of metal, which in practice may take the form of metal tubing (about ½ in. diameter) enclosing the "slot". This provides an aerial which is comparatively simple mechanically, and which does not offer the wind resistance of conventional slot assemblies. Directive arrays may be formed by adding directors or reflectors, though these will be mounted at 90° to the major axis of the slot. The feeder is normally matched to the mid-points of the slot (where the impedance may be as high as 600 ohms) by means of a quarter-wave stub or a linear transformer section.

AERIALS FOR BAND III

On the higher frequencies of Band III the voltage induced in a dipole element is appreciably less than that induced in a Band I dipole in an area of similar signal strength, while the losses in feeder cables will be approximately doubled; furthermore, the sensitivity of a receiver will not be so good on Band III as on Band I. For all these reasons, greater care has to be taken if good signals are to be presented to the receiver on Band III. On the credit side, however, the shorter elements make multi-element arrays relatively simple to construct and, in fact, arrays of ten or so elements mounted on a single cross-arm are available. These are highly directional, and great care should be taken to orientate them correctly in order to obtain the optimum results.

When planning aerial installations for both bands, the following questions need to be answered before any decision can be made as to the best type for a given location:

(1) Are the transmitters co-sited or located in different directions from the receiver?

(2) Is the location within the primary service area (*i.e.*, high signal strengths) of one or both stations?

(3) Is a Band I aerial already installed? This may enable a Band III aerial adapter kit, as available from most aerial manufacturers, to be used.

(4) Is the feeder run comparatively short (not more than about 50 ft.), or will a long cable run be required? Loss of signal in short runs is usually unimportant, but this will not be the case with long runs on Band III.

Undoubtedly, one of the major sources of difficulty with Band III aerials is the greater number of "ghost" images that occur on these transmissions. Hills, gasholders, spires, steel structures and many other reflecting surfaces may give rise to strong signals, arriving slightly out of phase with the direct signals, and thus producing ghost images slightly displaced from the main ones. These can often be eliminated by very careful orientation of the aerial, sometimes suffering some reduction in strength of the main signal.

On Band III, poor aerial siting or installation can seriously impair picture quality even within a comparatively short distance from the transmitter. Manufacturers have drawn attention to the advantages of an aerial sited above the chimney stack and as far as possible from obstructions; or failing this erected so that the chimney is to the side of, or behind, the aerial. Loft aerials for Band III are often rendered useless by the proximity of the water tank.

The following are among the suggestions put forward by a prominent manufacturer:

Install an outdoor aerial.

Have it on a high chimney.

Use a good-quality low-loss feeder cable.

Use the sensitivity control on the receiver to obtain a good picture on the weaker signal.

Use an attenuator on the stronger signal to equate the two signals.

Remember that multi-element aerials are very directional, and even a few degrees off beam will make a big difference.

Band I/Band III Tuned Filters

Filter units for separating or combining Band I and Band III signals—known variously as "cross-over filters", "diplexers", "splitters", etc.—have a number of uses. For example, such a unit is necessary where separate Band I and Band III aerials are used with a receiver having a single input socket, or alternatively where a combined Band I/Band III aerial is used with a receiver having separate input sockets. Two filter units may be useful where separate aerials and separate input sockets exist in those locations requiring long low-attenuation feeder cables; in these circumstances the cost of two filter units may be less than that of the length of cable which is rendered unnecessary by the use of one filter mounted close to the aerials and a second filter at the receiver end of the feeder cable.

FEEDERS

At radio frequencies a length of feeder cable may be considered as a series of resonant tuned circuits. By variations in ratio

TABLE 10.3.—TYPICAL ATTENUATION LOSSES IN FEEDERS

Type of Cable	Impedance (Ohms)	Attenuation loss (db/100 ft.) 50 Mc/s	200 Mc/s
Solid polythene co-axial	75	2·9	6·4
Cellular polythene co-axial	75	2·3	4·9
Semi-air-spaced co-axial	75	1·6	3·5

of inner to outer conductor and conductor spacing, cables having wide limits of characteristic impedance are possible.

Whilst the terminating impedance of a television dipole aerial is about 72 ohms, that of a multi-element array for use in fringe areas, etc., may be as low as 15 ohms, and is frequently about 40 ohms. The matching of a suitable feeder is thus a matter of considerable importance.

In the case of unscreened twin cables, the impedance and attenuation characteristics are quoted for a cable length in free air, and thus the proximity of metallic objects must be considered when carrying out an installation. Adverse effects are negligible with 72-ohm twin, but very important with higher impedance.

The semi-air-spaced type of cable provides a useful low-loss co-axial feeder. Unfortunately it cannot be extended to small balanced screened cables because of physical limitations.

Absorption Trap

This device consists of an electrical quarter-wavelength of feeder cable similar to that used for the aerial downlead, the outer conductor of which is connected to the outer conductor of the aerial feeder at the receiver end; the two inner conductors are also joined together. It is of great value where sound transmitters cause interference.

The length of the quarter-wavelength cable should be reduced by cutting its free end until the interference is eliminated.

The Use of Cables as Transformers

Although a stub-matching device to correct impedance is usually provided, instances may arise where the installation engineer has to provide a matching transformer. A quarter-

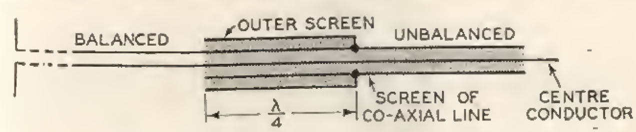


FIG. 1.—TRIPLE CO-AXIAL ONE-TO-ONE TRANSFORMER.

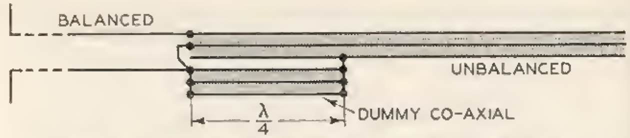


FIG. 2.—ALTERNATIVE TYPE OF QUARTER-WAVE TRANSFORMER.

wavelength of double-screened cable, connected as in Fig. 1, gives a 1 : 1 transformer between balanced and unbalanced lines. The quarter-wavelength refers to the co-axial formed by the two screens; the insulation between which should be polythene rather than P.V.C.

Alternatively, the method shown in Fig. 2 may be used; it uses an extra quarter-wavelength of the co-axial line. The quarter-wavelength refers to the balanced line formed by the two screens of the co-axials, the velocity of this line being controlled by the composite dielectric of sheaths and air between the two screens. The balanced load is connected between the screens of the main and dummy co-axials, the latter being connected to the inner of the main co-axial, and also short-circuited to the screen of the main co-axial at a distance of a quarter-wavelength from the junction.

The use of a half-wavelength cable provides a 4 : 1 transformer, and is useful for connecting a high-impedance balanced load (*e.g.*, a folded dipole or open-wire feeder) to a co-axial, see Fig. 3. The inner conductor of the co-axial is connected to one side of the balanced load and to a further half-wavelength of similar co axial. The inner conductor of this short length is connected at the far end to the other side of the balanced load.

Matching Television Aerials to Feeder Cables

The addition of parasitic elements reduces the impedance at the centre of a half-wave dipole. This mis-match which occurs when an H type aerial is connected to, say, an 80-ohm cable is generally regarded as insignificant, but with multi-element arrays some means must be found of overcoming this difficulty.

Two popular methods of raising the effective impedance are: (1) by the use of folded dipoles, and (2) by the insertion of a quarter-wave transformer.

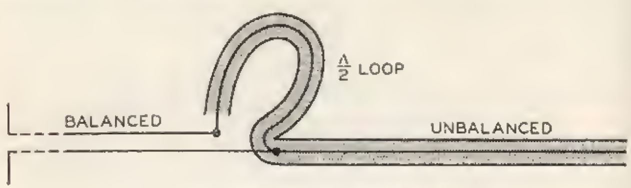


FIG. 3.—FOUR-TO-ONE TRANSFORMER

The folded-dipole consists of two or more half-wave aerials with their ends connected together, running parallel and closely spaced to one another, with the feeder cable connected to the centre of only one of the elements. With two similar elements such an arrangement provides an impedance step-up of 4 to 1, and three elements 9 to 1. A wide range of step-up ratios can be obtained by using elements of dissimilar-diameter tubing.

The quarter-wave transformer consists of the appropriate length of transmission line inserted between the aerial and the feeder cable. The characteristic impedance of the transformer is given by the formula:

$$Z_t = \sqrt{Z_1 \times Z_2}$$

where Z_t is the characteristic impedance of transformer;
Z_1 is the characteristic impedance of the feeder cable;
Z_2 is the impedance of the aerial.

Two other methods occasionally used are: (1) to make use of the relatively high impedance at the end of the dipole, and (2) by T matching the cable to the aerial element. In the case of (1), which is practical only with arrays using four or more elements, a step-down quarter-wave matching stub is usually required. With (2) the feeder wires are connected not to the centre of the dipole but to points a few inches above and below the centre. Both of these methods are inclined to reduce the band-width and to make the dimensions rather critical.

ATTENUATORS

The two types commonly used are the "pi" and the "T". The "pi" is more suitable for test purposes, as it uses higher resistance values. Fig. 4 (*a*) shows the circuit, and resistance values for different attenuation requirements are given in Table 10.4.

TABLE 10.4

Required Approximate Attenuation, db	*R1, Ohms*	*R2, Ohms*
10	150	100
20	470	100
30	1,500	82
40	3,900	82
50	10,000	82
60	39,000	82

Resistors should be of $\frac{1}{4}$-W normal rating, with tolerance of ± 10 per cent, non-inductive.

The "T" type circuit is shown in Fig. 4 (*b*). Above 20 db attenuation this type is not suitable, as the resistance value of

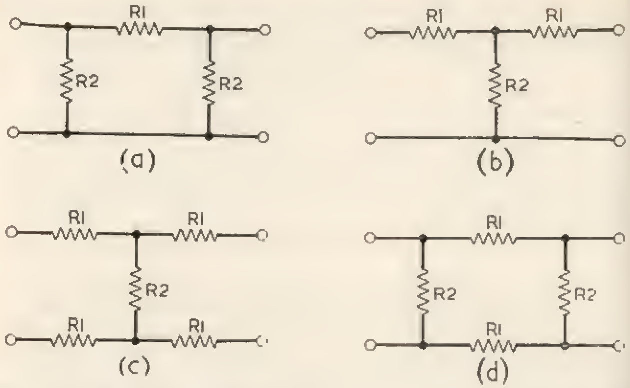


FIG. 4.—ATTENUATORS: (*a*) "pi" TYPE; (*b*) "T" TYPE; (*c*) "T" TYPE FOR BALANCED TWIN FEEDERS; (*d*) "pi" TYPE FOR BALANCED TWIN FEEDERS.

R2 becomes too small. Resistance values are given in Table 10.5.

TABLE 10.5

Required Approximate Attenuation, db	*R1, Ohms*	*R2, Ohms*
10	39	56
20	68	16

The circuits given are for use with co-axial feeders. Where balanced twin feeders are used the value of R1 should be halved and the circuits are as shown in Fig. 4 (*c*) and (*d*).

AERIAL INSTALLATION

The recognised method of attaching an aerial to a chimney stack is by the use of a right-angle bracket engaging on a corner of the stack and tensioned against it by a wire lashing located around the stack. The object is twofold. Firstly, it avoids hammering holes in the brickwork and thus weakening the stack, particularly in the case of old property. Secondly, it avoids the legal implications of landlord's fixtures, and the aerial may therefore be subsequently removed by an outgoing tenant if he is the owner. Brackets are usually cast in high-tensile aluminium alloys to avoid the need for protective finishes.

Suitable lashing wire is galvanised 7/16 s.w.g. high-tensile steel wire, the tensioning being taken up by J bolts, which are located on the corner bracket and are hooked into ferrules spliced

on to the lashing wire. To avoid chafing, the lashing wire passes over small angle brackets located at the three remaining corners of the stack, held in tension by the lashing wire. Single-flue chimneys are generally considered unsatisfactory for Band I aerials; two-flue chimneys are suitable for most normal installations, but four-flue chimneys should be used for heavy multi-element arrays unless the mast is "stayed". Wherever possible the aerial elements should be kept clear of the chimney outlet to avoid damage when the chimney is swept and deterioration due to smoke contamination.

Feeder cables tend to deteriorate rapidly where long stretches, either vertical or horizontal, are left without proper anchoring and are thus subject to continuous strain from their own weight or to grazing by wind action. Where cables come down over tiled roofs suitable tile clips, such as Francis wall nails, should be used to anchor the cable by careful insertion under the tiles. Preferably the cable should be fastened at intervals not greater than 3 ft. for vertical runs and 1 ft. for horizontal runs. Where soft lead or other metal nails or electricians' cleats are used to secure the feeder to roofs and outer walls, a small piece of fibre or tape should be wrapped around the cable to prevent the fixing metal from puncturing the outer sheathing. The fixing cleat should not be hammered home too hard, otherwise the cable will be subject to excessive pinching and the sheathing may be punctured, allowing moisture to enter, with consequent loss of signals. The feeder should be looped slightly away from any woodwork so as not to interfere with painting. Where the feeder is routed externally to the mast it should be taped to the mast using water-proof tape. It should be taken behind guttering and on to the gutter board or alternatively stand-off brackets should be used.

At the point where the feeder enters the building a water-drip loop should be formed in the feeder and entry holes should be drilled at an angle of 45 degrees downwards from the inside.

No matter how good the aerial installation, considerable deterioration takes place under continuous exposure to a smoky atmosphere and variable weather. Therefore to maintain its efficiency, regular inspection and repainting should take place, preferably at intervals not exceeding two years.

Multi-receiver Installations

Where there is only one convenient mounting point for two houses or flats, it is often more satisfactory to feed two receivers from a single aerial rather than to place two aerials in close proximity. This can be done without difficulty, provided that the signal strength in the area, for the type of aerial system employed, is sufficient to permit a loss of 6 db from the signal which would be fed to a single receiver. Star networks which enable two receivers to be fed from a single co-axial or twin-feeder line are shown in Fig. 5.

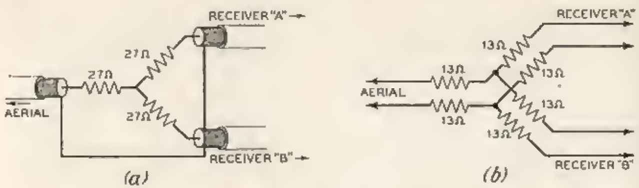


Fig. 5.—Star Networks: (*a*) Co-axial Feeder; (*b*) Twin Feeder.

Where it is desired to operate a large number of receivers from one aerial without loss of signal, as may be the case in a service workshop, a block of flats or a hotel, it is essential to ensure that there is no interaction between receivers, and that all outlets receive a satisfactory signal. This will normally entail the use of a distribution amplifier in conjunction with an efficient aerial, suitable cable runs and correct socket outlets. The distribution amplifier should be fitted as near to the aerial as possible, and suitably accommodated in a dry, weatherproof room or enclosure, properly ventilated and reasonably free from dust. Flue gases or smoke should not be allowed to enter the amplifier enclosure, as otherwise rapid corrosion of metalwork may be experienced. Where exceptionally long cable runs are necessary, it may be advisable to use air-spaced co-axial cable.

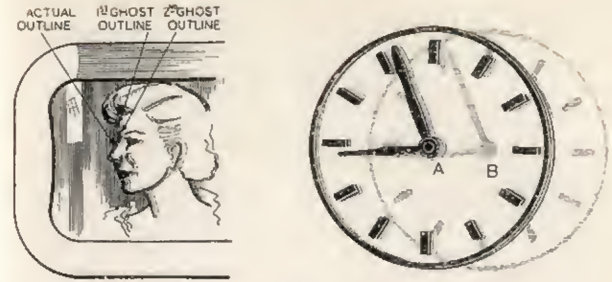
Fringe-area Equipment

Since valve noise becomes increasingly important as the input to the first R.F. stage falls, losses in the feeder line are often the decisive factor in determining whether or not a satisfactory picture can be obtained in a fringe area. Special low-loss air-spaced cables are available for fringe area installations.

Since special feeder cables are considerably more expensive than the standard types, it will be necessary, in many border-line cases, to weigh carefully the relative costs of the various types of aerial arrays, high masts, pre-amplifiers, cables and the like. For example, it may be found more economical to use a more complicated array with standard cable than a simple aerial with special cable, or vice versa.

" Ghost Images "

Reflection of signals from natural and man-made objects may cause a double or multiple image to appear upon the screen of a receiver; and in certain districts such conditions may prove most troublesome and difficult to overcome. Hill faces are probably the most frequent cause of " echo " signals, but almost any reflective surface, such as trees, buildings, gasometers, or factory chimneys, may give rise to " ghosts ". By measuring the displacement of the spurious image, a rough estimate may be made of the distance of the offending objects.



(*a*) (*b*)

Fig. 6.—Ghost Images.

The approximate image-displacement values and distances of the reflecting structure from the aerial for a 15-in. cathode-ray tube are given in Table 10.6.

Intermediate angles between the rear and side-on positions will give intermediate values between those shown in the middle and right-hand columns. Objects slightly in front of the side-on view would be at a distance greater than that given by the middle column.

The cure of double images is still largely a matter of trial and error in the positioning and orientation of the aerial: the principle being the adjustment of the system to give minimum pick-up of the " ghost " reflection. It is, for example, useless in areas prone to " ghosts " merely to point the aerial towards the transmitter. Instead, the aerial should be carefully adjusted when a programme, preferably Test Card " C ", is being received.

Table 10.6

Displacement of Image	*Object to Right or Left*	*Object Immediately Behind*
$\frac{1}{16}$ in.	110 yards	70 yards
$\frac{1}{12}$ "	190 "	95 "
$\frac{1}{10}$ "	220 "	110 "
$\frac{1}{8}$ "	280 "	140 "
$\frac{1}{4}$ "	560 "	280 "
1 "	1¼ miles	1100 "
2 "	2½ "	1¼ miles

In some cases it may prove easier to reject the direct signal and concentrate on receiving the reflected signal, for example by turning the aerial on its side so as to receive horizontally rather than vertically polarised waves. With indoor aerials, a change of position of only a foot or two may make a considerable difference to results.

[SECTION 11]

INTERFERENCE

The very high frequencies (30–300 Mc/s) on which television broadcasting at present takes place, are particularly susceptible to interference from local electrical appliances and spark-ignition systems, the interfering signals arriving at the receiver either by direct radiation from the source or by conducted radiation along power mains and overhead wiring, or by a combination of the two.

The Engineering Branch of the G.P.O is prepared to assist licence holders in the tracing of man-made interference and to offer advice on its suppression. Applications for assistance, which is provided free of charge, should be made by licence holders on Form T.466G "Electrical Interference Questionnaire", obtainable from any Head Post Office.

It is, however, of considerable importance that the installation and servicing engineer should be able to distinguish between local interference and receiver faults, to recognise the various types of interference from the symptoms they produce upon the picture and to know what can be achieved by the installation of suppression devices to minimise the effects of such interference.

In practice, interfering signals fall into two main categories, which require entirely different treatment: the impulse type of interference producing spots or lines of peak white across the screen, and continuous wave signals on frequencies falling within the acceptance band of the receiver and producing heterodyne interference in the form of a "herring-bone" pattern of alternate dark and light bands running diagonally across the screen.

Impulse Interference

Electrical apparatus which utilises commutation (*e.g.*, D.C. motors and generators), vibrating contact points (*e.g.*, electric shavers), spark discharge (*e.g.*, automobile ignition) or any mechanism whereby an electric spark, however minute, is produced will radiate R.F. waves, covering a wide frequency spectrum, unless preventive measures are taken. Such signals will cause crackling on sound and a series of white spots or bright streaks of light on the screen. In this category must also be included switching circuits, such as thermostats and dirty light switches, where slight arcing may take place. As with all forms of interference, the effect will largely depend upon the ratio of the levels of the interfering signal to the picture signal, and will thus be more severe in "fringe" areas.

By far the most satisfactory cure is the suppression of such interference at the source: ignition interference, for example, can be greatly reduced by the fitting of a resistor of about 15,000 ohms in the lead from the distributor to the induction coil or magneto; while most small electric motors as fitted to domestic appliances will respond satisfactorily to the fitting of a capacitor, or capacitor-choke filter, which will provide an alternative path for the R.F. pulses, and which should be positioned close to the offending apparatus. An increasing proportion of home appliances include built-in suppressors, but for other apparatus a wide range of proprietary filters are now manufactured; typical circuits are shown in Fig. 1.

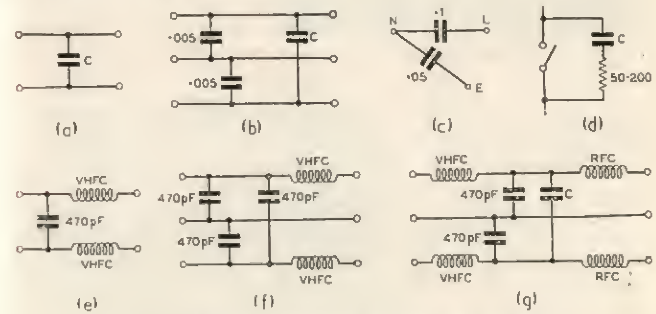


FIG. 1.—BASIC INTERFERENCE SUPPRESSION DEVICES.

(*a*) For two-core cable appliances. (*b*) For three-core cable appliances. (*c*) For three-pin socket. (*d*) For thermostats. Types (*e*) and (*f*) are for the suppression of television interference from two- and three-core appliances. (*g*) All-wave filter for broadcast and television interference suppression. The value of C may vary between 0·01 and 0·5 μF. Values given for type (c) are the largest permissible.

Where the source is unknown or cannot readily be suppressed, the effects can be reduced by: (1) the provision, on the sound and vision receiver units, of interference limiter circuits, designed to cut off the high amplitude peaks of the interfering signals—popular circuits for such limiters are shown in Fig. 2 (*a*)–(*d*) (in practice the valve diodes are sometimes replaced by germanium crystal diodes)—or alternatively, by inverting the pulses so that they produce black instead of white spots (see pages 45–46); (2) ensuring that the most efficient aerial system is employed, with the elements as far away as possible from the source of interference or from wires and guttering that could form conduction paths; (3) where the source of the interference is known, as, for example, the cars passing along a main road, a directional aerial system may be orientated so as to provide minimum pick-up from this direction; (4) the use of interference filters in the mains supply leads to the receiver. Method (4) is unlikely

to prove as effective at television frequencies as for normal broadcasting frequencies owing to the greater ease with which the leads before and after the filter can act as aerials and thus allow the interference to bridge the filter; nevertheless, a number of filters especially designed for use at television frequencies are now on the market, and will often bring about a considerable improvement, particularly when used in conjunction with methods (1)–(3).

An effect somewhat akin to ignition interference may be caused

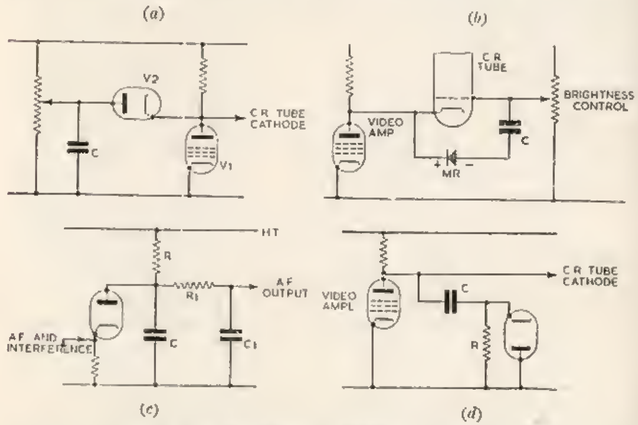


FIG. 2.—INTERFERENCE-SUPPRESSION CIRCUITS.

(a) Basic vision-interference suppression circuit. (b) Automatic form of peak limiter. (c) Typical pulse-width limiter circuit. (d) Vision-interference limiter operating on a time-constant basis.

by corona discharge ("brushing") from points at E.H.T. potential, but it can easily be recognised by its more continuous nature.

Heterodyne Interference

The second and less common group of interfering signals are those in which oscillation is continuous, as opposed to trains of damped oscillation, and these are usually tunable over a comparatively narrow band; they produce heterodyne interference, against which peak limiters and suppression filters of the type so far described are ineffective. The most common causes of such interference are diathermy apparatus, adjacent-channel interference, harmonics of short-wave broadcasting, communication and amateur transmitters, and radiation from the local oscillator of other television or short-wave receivers. Susceptibility to certain forms of this interference particularly, for example,

to break-through on the intermediate frequency of the television receiver, will depend very largely upon the inherent design of the receiver and the choice of the intermediate frequency.

The interference may arise from radiation (usually harmonic) taking place at frequencies within or close to the television channel (in this case suppression at the source or careful orientation of the receiving aerial are likely to be the only effective cures); to image (second channel) response in the receiver; from "blanketing" or swamping of the receiver by very strong local signals, or cross modulation, sometimes produced by rectification in the aerial system or local metalwork; from break-through of a signal on a frequency close to the intermediate frequency; or from a combination of these. By fitting suitable traps and filters in the offending transmitter, and by careful screening, harmonic radiation can be much reduced. Rejection of fundamental or intermediate frequency signals can often be improved by screened

FIG. 3.—IGNITION INTERFERENCE.

FIG. 4.—INTERFERENCE CAUSED BY ELECTRIC MOTORS.

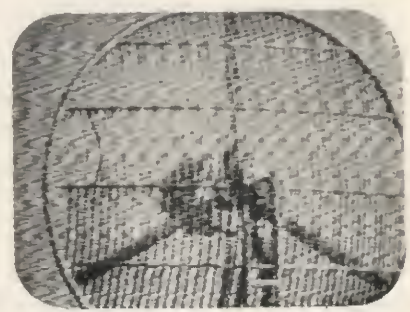


FIG. 5.—MODULATED R.F. INTERFERENCE.

traps or filters in the aerial feeder of the receiver, close to the receiver, or alternatively as close as possible to the control grid of the first R.F. amplifier or mixer valve. Such a wave trap resembles those used in the early days of broadcasting, and is tuned to the unwanted frequency (provided that this does not lie within the required television channel). A coil with 10 turns of 18 S.W.G. wire, spaced wire diameter, and with an internal diameter of $\frac{5}{16}$ in., tuned by a 3–30-pF trimmer, will have a tuning range of about 40–50 Mc/s, and for offending signals on other frequencies the number of turns should be increased or decreased accordingly. For the rejection of signals at intermediate frequencies, high-pass filters with a pass band of about 40–60 Mc/s may be fitted in the aerial lead of the receiver, and will normally prove effective provided that the screening of the I.F. stages is adequate to prevent direct pick-up. Here again, careful positioning and orientation of aerials may prove of assistance.

FIG. 6.—SEVERE DIATHERMY INTERFERENCE.

Diathermy

This is a particular form of heterodyne interference, the cause in this case being the harmonic output from the relatively unsmoothed valve oscillators used in electro-medical apparatus. In addition to the herring-bone pattern, the sound channel is often affected by harsh crackling or low-pitched hum. The most satisfactory cure for this form of interference is the complete electrical screening of the offending apparatus; though in some cases relief can be obtained by slightly changing the frequency of oscillation of the equipment so that the harmonics no longer fall in the television channel concerned.

Freak Propagation

Owing to the fact that television channels are shared on a geographical basis, herring-bone interference patterns may sometimes be caused by signals being received from a distant

station, normally inaudible. The most common cause of such a propagational condition is a period of "Sporadic E", when the E layer becomes highly ionised and reflects signals up to about 70 Mc/s over distances between 200 and 1,000 miles. Pronounced temperature inversions, such as occur during summer evenings, may also cause slight interference. As such conditions seldom last for long, it is usually considered unnecessary to take precautions against this form of interference.

Aircraft Flutter

Reflection of signals from aircraft may provide alternate augmentation and attenuation of the signal as the phase of the reflected signal changes in relation to that of the direct signal; this will cause the contrast of the picture to change rapidly from normal to low and then to high, the cycle being repeated in rapid succession for as long as the aircraft is in the neighbourhood.

The degree to which a particular receiver installation is susceptible to this form of interference will largely depend upon the aerial system: a system which receives only vertically polarised signals will generally be less affected than one capable of responding to the horizontal component. The effects may also be diminished by reducing the D.C. coupling to the cathode-ray tube, or by the use of some form of automatic picture control.

Interference by Television Receivers

Radiation of parasitic oscillation occurring in a television receiver may affect local broadcasting and television receivers: the cure here is to find the source of the parasitic oscillation and to improve the stability of the offending stage(s).

Radiation in the form of induced electric and magnetic fields may be set up in the neighbourhood of a television receiver, and may affect nearby broadcasting receivers, particularly on the long-wave band. The most likely sources of these fields are the line-output transformer and associated points at E.H.T., the deflector coils and the high-impedance circuits near these components. The following methods of reducing such interference have been recommended by Messrs. Mullard, Ltd.:

(1) The E.H.T. transformer, booster diode and line-output valve should be totally screened by a can which makes good contact with the chassis. Two-hole fixing of the can is not entirely satisfactory, and it is advisable to make multiple connections between can and chassis. The difference in radiation between a good and a bad connection here may amount to as much as 8 db for magnetic fields.

(2) Any width or linearity controls of the inductor type should be screened separately if they cannot be accommodated inside the line-output screening can. (The design of the line-

TABLE 11.1.—CAUSES OF TELEVISION INTERFERENCE INVESTIGATED BY THE G.P.O. DURING A TYPICAL TWELVE-MONTH PERIOD

Cause	*Number*
Unknown: not observed by P.O. staff	13,972
Sewing-machine motors	9,936
Faulty receivers	4,273
Hair-dryers	4,155
Inefficient aerial-earth systems	1,827
Motor-car ignition	1,778
Motors, miscellaneous	1,617
Drills	1,521
Vacuum cleaners	1,452
Lamps (filament type)	1,193
Fan motors	1,069
Overhead power lines	1,062
Refrigerators	937
Bed-warmers	766
Thermostats, miscellaneous	755
Radio transmitters	698
Radiation from superhet local oscillator	650
Neon-sign tubes	615
Medical apparatus (valve)	439
Mis-operation of receivers	410
Hair-clippers	361
Faulty wiring of buildings	301
Electric toys	281
Dental motors	254
Bells	241
Fluorescent tubes	176
Rotary converters	163

output screening involves problems of ventilation to avoid overheating of the components enclosed by the screen. (As a general guide, the maximum safe bulb temperature for the PL81 line-output pentode has been determined at 185° Centigrade.)

(3) The deflector coils should be screened as far as possible by an aluminium can or by metal foil wound co-axially around the coil and earthed to chassis. Care must be taken to ensure that there is no likelihood of voltage breakdown between the foil and the coils. This form of screening will give good reduction of electric fields, and will also reduce magnetic fields, though not to the same degree. To reduce the magnetic field still further, the deflector coil-screening can should have endplates with holes only just large enough for the tube neck to pass through. This gives a further reduction of approximately 6 db.

(4) Care should be taken in the layout of the receiver to keep circuits of high impedance well away from the worst sources of interference.

(5) The graphite coating of the cathode-ray tube should be efficiently connected to earth—preferably from two separate points on the coating.

(6) Both conductors of the mains supply should be connected to the earth terminal via 0·05-μF paper capacitors rated for 600 V (r.m.s.) working.

(7) The use of a perforated foil screen at the back of the set will reduce radiation in that direction.

As already mentioned, interference with radio reception can be due to both electro-static and electro-magnetic induced fields: the magnetic field will affect only receivers with frame aerials. Interference is most commonly caused on the Droitwich long-wave programme (1,500 m., 200 kc/s) since the 20th harmonic of the television line-scan frequency falls at 202·5 kc/s.

Where the interference is not serious enough to warrant alterations to the receiver, much can be done to avoid interference on a neighbour's radio receiver by carefully selecting the position of the television receiver. As back radiation is usually the most serious, receivers should not be installed against a party wall unless it is known that there is no radio receiver on the other side.

A less frequent cause of interference in radio reception—and also in television reception—is parasitic or Barkhausen–Kurz oscillations, particularly in the line-output stage. On the television screen such interference may take the form of irregular vertical white lines about 2 in. from the left-hand side of the screen. A cure can often be effected by changing the line-output valve, altering the position of the line-hold control or by the use of parasitic suppression devices.

A wavering vertical line, similar to that described above and often known as " windscreen wiper " interference, is usually due to line time-base radiation from a nearby receiver tuned to another station. The interference will not be visible if both sets are tuned to the same channel, as the radiation occurs mainly during the flyback period when the picture is suppressed.

Patterning interference from Band I receivers converted by means of a " universal " converter is also fairly common. This is discussed in Section 7.

Where two receivers in close proximity are tuned to different transmissions, sound and/or vision interference may arise from radiation at the common intermediate frequency. This is best cured either by moving one of the sets or, if not possible, by fitting a high-pass filter in the aerial lead of the affected receiver to prevent breakthrough of signals at the intermediate frequency.

Figs. 3, 4, 5 and 6 are " Tele-Snaps " by John Cura.

[SECTION 12]

FAULT FINDING

by T. B. Smartt

The tracing of faults in television receivers can frequently present unexpected difficulties to an engineer who possesses impressive theoretical knowledge but who lacks practical experience. It is not enough to know how a television set works: unless a thorough basic knowledge of radio is supplemented by considerable practical experience, vital time will be lost and effort misdirected before the cause of a breakdown is finally revealed.

Preliminary Considerations

If radio and television repairs are to be carried out on a sound economic basis, the engineer must be able to use his past experience of the weak points of particular models to enable him to locate at once the cause of the trouble. Often a telephone message from a customer reporting the failure will start the engineer thinking of the most probable cause of the breakdown. If the message has come via the shop, then the repair slip may contain the vital clue. In any event, unless the lengthy process of systematic examination can be circumvented in a fair proportion of instances the repair department will not pay its way.

The engineer who is most successful in tracing faults is usually the man with a retentive memory and a keen eye for detail. When a chassis lies on the bench for examination, the eye and sometimes even a keen sense of smell may lead to the cause of the trouble before the use of a meter has been considered. The customer often reports " a smell of burning " after switching on. The engineer, anxious to save time, will at once watch for a cracked or blistered resistor. Once located, the cause of failure—sometimes an associated by-pass condenser—can be verified and the faulty components replaced.

Instances of complete breakdown are usually the easiest faults to trace. More difficult are the cases where the set works but picture quality has deteriorated or is subject to intermittent faults which require more lengthy examination.

For the purpose of fault tracing, the television set may be conveniently divided into sections. In addition, it is very useful to have a clear mental picture of the type of waveform normally associated with various parts of the circuit. The majority of service manuals are very helpful in this respect, as many include both waveforms and a voltage analysis taken under stated conditions of operation. When dealing with faults in the time-

base with the aid of an oscilloscope, much time can be saved once the habit of forming a mental picture of the shape and amplitude of the normal trace has been acquired. It is recommended that the service engineer should undertake a detailed study of time-bases, as it is in this section of the television set that the most frequent failures occur.

Faults in R.F. Stages

Faults other than that of valve failure in the R.F. stage are not frequently met. On turning the contrast on full the remainder of the set will produce fluctuation noise, which will be apparent both from the loudspeaker and the tube raster. The time-bases will be running freely, and the lower-pitch whistle from the line-output transformer will indicate the lack of synchronising pulses from the carrier. Quick verification of the faulty stage can be obtained by connecting the aerial to the input grid of the frequency changer. The tracing of a faulty R.F. stage should present little difficulty, but as the method involved also applies to receivers built on the T.R.F. principle and I.F. amplifier stages, the steps to be taken are worthy of some consideration.

In areas of weak signal strength the aerial should first of all be checked for a possible short-circuit or open-circuit in the co-axial connection to the grid tuning coil. If the fault is at the dipole connection, and the centre conductor has become disconnected, some indication of signal can be obtained by making a temporary contact between the braiding and the centre connector of the co-axial input socket on the receiver. If the aerial is in order the grid circuit of the first stage should be examined for a possible dry joint or open-circuit. If the correct D.C. potentials are on the anode and screen of the valve, the cathode return circuit should be checked for an open-circuit.

Component Deterioration

Quarter-watt resistors, when of more than 1,000 ohms in value, and included in the anode circuit of an H.F. stage for the purpose of de-coupling, can cause trouble by overheating and increasing in value. As a rule it is advisable to replace any such components by equivalents of half-watt rating. During the course of examination of the vision strip it is sometimes very helpful to tap all components lightly with an insulated probe. A microphonic valve or a condenser with an intermittent fault can often be located by this method.

Ordinary radio sets are usually quite tolerant of R.F. de-coupling condensers that, during the course of years, have developed leaks and are in effect resistors. In the case of television receivers, however, the standard of circuit efficiency is far more exacting, particularly when the most has to be made of a weak signal. When a receiver of the T.R.F. type has been in operation for a number of years, and routine checking of valve emission and circuit voltages fails to reveal the cause of low

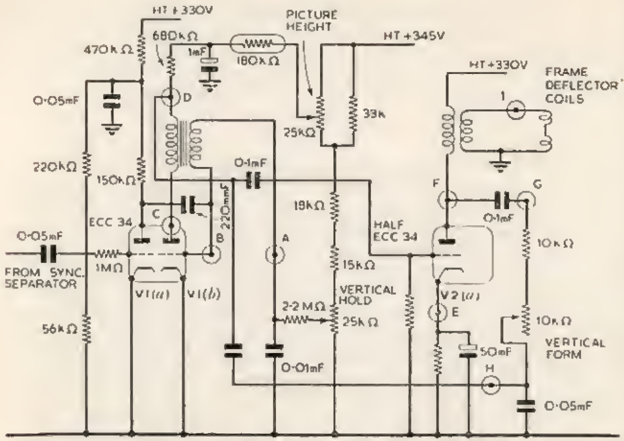


FIG. 1.—TYPICAL EARLY FRAME TIME-BASE.

In this circuit V1(*a*) is used to shape the synchronising pulses which trigger the blocking oscillator V1(*b*); this drives the amplifier V2(*a*). The waveforms occurring at points A–I are shown in Fig. 2, and provide a ready means of tracing faults.

modulation on the cathode-ray tube, it is worth while testing for " leaky " components in the signal-frequency stages.

R.F. and I.F. Instability and Loss of Signal

Cases of R.F. or I.F. instability, usually apparent through uncontrollable peak white modulation on the tube, can be traced quickly by connecting the grids of the amplifier stages to the chassis, starting at the point of the lowest signal. As a rule, the T.R.F. type of receiver is more inclined to develop this kind of trouble than the superhet. A faulty valve-holder quite often proves to be the cause of such instability. If all valve connections prove to be in order, then the possibility of feedback through the wiring of the set should be examined. The position of the aerial feeder relative to the final amplifier stage should be considered, as feedback is most likely to occur between points of high and low signal amplitudes.

Apart from incorrect alignment, loss of vision signal can sometimes be due to incorrect adjustment of rejector circuits. This condition is usually indicated by vision-on-sound interference in the loudspeaker. The cure is best effected by re-aligning the receiver throughout. In the case of the superhet, lack of signal in both vision and sound sections can be due to failure of oscillation in the frequency changer. This is commonly due to either loss of emission or a low voltage on the anode of the oscillator valve. Amplifier stages should be checked for o/c. by-pass condensers.

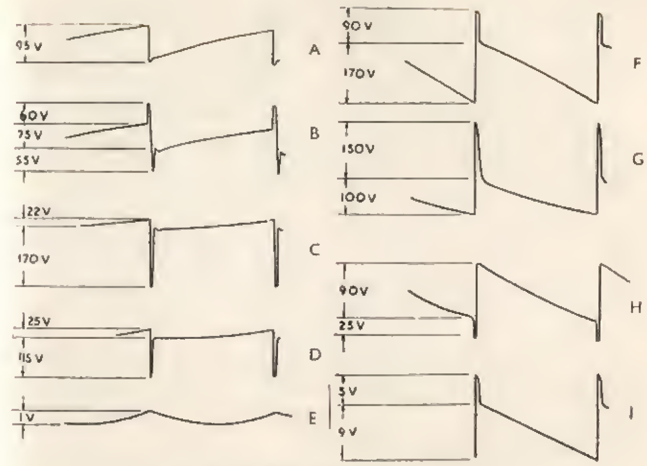


FIG. 2.—WAVEFORMS ASSOCIATED WITH FIG. 1.

Faults in Video-amplifier Stage

If the television receiver is considered in two sections, from the aerial to the detector, and from that point to the cathode-ray tube, it is in the second section that the majority of faults are found to occur. The video detector itself can cause a fault which may at first sight be wrongly attributed to a weak signal from the vision strip, or alternatively to a loss of drive from the video amplifier. If the detector is of the thermionic type, failure in emission will result in a weak picture, loss of synchronisation in the line and frame time-bases—in short, a number of puzzling " red herrings " confront the fault tracer. It is well to remember that crystal detectors are also liable to breakdown.

The video-amplifier valve handles the rectified signal, and should be capable of useful gain over a frequency range extending to 3 Mc/s. The quality of the television picture depends on the efficiency of the video stage, and on the correct degree of frequency compensation which is applied to this circuit. In some video stages the value of the anode load is kept as low as possible. If quarter- or half-watt resistors are used in this part of the circuit, and there is evidence of over-heating, it is advisable to replace the resistors by 2- or 3-W equivalents. Valve efficiency is rather critical in the video stage, and any falling off in emission will often cause an unsatisfactory picture, with poor synchronisation if the signal strength is low.

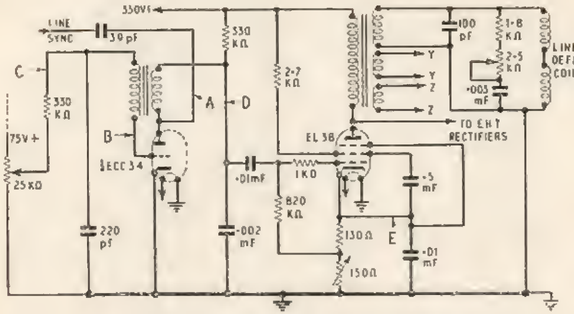


FIG. 3.—TYPICAL EARLY LINE TIME-BASE.

In this circuit, half an ECC34 is used as a blocking oscillator, triggered by the line-synchronising pulses: the output is then amplified by an EL38. The waveforms which occur at points A–E, and which form a ready means of fault tracing, are shown in Fig. 4.

Faults in Cathode-ray-tube Circuit

For reasons of economy and efficient circuit design, cathode-ray tubes are cathode driven, and are usually directly coupled to the anode of the video amplifier. This connection is sometimes made through a resistor of about 100,000 ohms, by-passed at video frequencies by a 2-μF condenser of small size. The network is returned to earth via the high-potential side of the brightness control, thereby ensuring that the cathode-ray tube grid can never go positive with respect to the cathode. Some components associated with the cathode circuit of the tube are concerned with the removal of impulsive interference. If this circuit fails to operate, the cause will almost certainly be the valve, which is biased to conduct on signals above peak white modulation level.

It is sometimes found that a brightness-control potentiometer with a worn track can produce a picture fault which may be confused with the symptoms of failure in the tube-heater-to-cathode insulation. The picture breaks up into strips of varying brightness, running horizontally, which resemble the blurred areas which occur during intermittent heater-to-cathode short-circuits.

Faults in Synchronising Separator

When faults occur both in the line- and frame-deflection circuits it is logical to trace the cause to a common origin, and the most likely component to suspect is the synchronising separator, which, owing to loss of emission or faulty resistors in either the grid or anode circuit, may be operating on the wrong part of the valve characteristic. If anode current changes are caused by picture content instead of being limited to the synchronising

pulses, then the time-bases will run so irregularly that it may prove impossible to lock the picture into a steady position. The cause of trouble in this case will often be traced to the 0·1-μF grid coupling condenser to the synchronising separator. This component should have a very low leakage current, and should show a resistance of about 20 megohms on test.

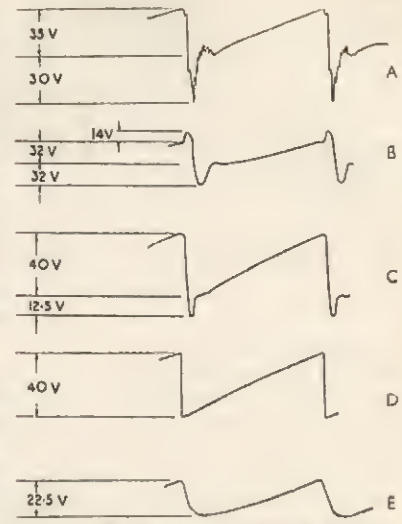


FIG. 4.—WAVEFORMS ASSOCIATED WITH FIG. 3.

Interlacing

Faulty interlacing of the picture-line structure is often due to unwanted coupling between the line and frame oscillators. Although it is very difficult to remove all trace of the line-synchronising component from the frame pulses, considerable success has been achieved in producing well-interlaced pictures in most modern receivers.

Imperfect interlacing produces a serious loss of picture definition in the vertical direction, and may, in extreme cases, produce a loss in horizontal definition through the over-lapping of adjacent line information. Apart from the obvious "liny" picture structure, faulty interlacing can be recognised by a tendency for the start of the half-line trace to wander at the top of the raster. This indicates that the frame time-base is not being triggered at the correct intervals by the frame-synchronising pulse. This irregularity is due to the variation in the intervals between successive fields caused by the uneven operation of the frame time-base. For correct interlacing, the shape and duration of the synchronising pulses must not vary. It is through the addition of small voltages at line frequency to the envelope of the frame pulse produced by the integrator circuit that faulty interlacing arises. As very small intervals are concerned in producing these waveform irregularities, the underlying cause is to be found in minor circuit variations due to faulty insulation in condensers. Induced voltages at line frequency in the frame-time-base circuits can arise from the inadequate screening of the line-output transformer or line-deflection coils.

The cure for some cases of faulty interlacing can only be discovered after considerable time has been spent, using the oscilloscope, in the systematic examination of the waveform at various points in the frame-scan circuit. In many modern receivers a valve or crystal diode stage separates the frame-synchronising pulses from the mixed waveforms in the synchronising separator. An oscilloscope applied to the anode and cathode of the "pulse shaper" should reveal clean-cut negative-going waveforms.

The presence of pulses at line frequency can be revealed in the frame circuit by rendering the frame oscillator inoperative either by removing the valve or disconnecting the H.T. supply. Under these conditions the use of the oscilloscope at various points in the frame time-base will reveal the extent of the coupling effects from the line oscillator. During this experiment both the aerial and E.H.T. supply should be disconnected.

Faults in E.H.T. Circuit

As the majority of modern receivers obtain their E.H.T. supplies from the rectification of high voltages generated in an inductance forming part of the load on the line-output pentode, failures in this part of the set will usually be caused by the strain imposed by the high induced voltages. The line-output transformer with the extra windings to supply the high-voltage rectifier should be a high-grade component throughout, and manufacturers will cut costs here at their peril!

Any partial breakdown in the insulation of the line-output transformer will be indicated by a characteristic fold-over on the side of the picture. If E.H.T. is also supplied from the winding there may be insufficient voltage to produce a picture. The faulty component may overheat until a complete winding breakdown occurs. The presence of a high potential on the cathode-ray-tube anode may be quickly verified by obtaining a brush discharge on to the blade of a well-insulated screw-driver. After a time the service engineer will become quite expert in assessing the E.H.T. voltages by this method. It is wise not to apply this test to mains-generated E.H.T. systems, which should be treated with extreme caution at all times.

Apart from breakdown in the line-output transformer, the E.H.T. supply may fail through a variety of additional causes, and faults in this part of the circuit are very common in some receivers. The presence of air inside the high-voltage rectifier may be recognised by a purple glow diffused throughout the envelope. If, however, the valve looks in order but still fails to develop E.H.T., the cause may be due to a short-circuit in the line-output deflection coils, especially if these components have a metal shroud. Extensive picture interference is commonly caused by corona discharge at high potential points. Careful listening or examination in subdued light will often reveal the source of the discharge. Seepage of E.H.T. across insulated surfaces due to dust and dampness can also cause this type of picture interference. Some manufacturers enclose the entire E.H.T. system in a screened compartment, and shorting across of the E.H.T. from the cathode of the diode to the metal case can occasionally occur. A slight movement of the diode away from the nearest earth potential point will speedily cure this fault. If lack of voltage pulses in the line-output transformer is indicated by the absence of the characteristic high-pitched whistle, then the lack of oscillation can be due to a failure in the line feedback circuit, or, possibly, to a faulty oscillator valve or blocking oscillator transformer. The use of the oscilloscope is again desirable for the rapid location of the fault. It should not be overlooked that quite high voltages can be found throughout the feedback circuit, and small mica condensers will sometimes fail or develop an intermittent fault producing picture interference.

Cathode-ray-tube Faults

The modern cathode-ray tube is a precision instrument, and should last in regular use for at least two years without serious deterioration. In the past the most common reason for tube replacement was the presence of a relatively insensitive area of tube fluorescence due to heavy ion bombardment from traces of gas in the tube. In most modern tubes this defect is overcome by means of the "ion trap", the presence of which is usually recognisable by the deliberate off-centre alignment of the cathode-gun assembly. A small permanent magnet clamped externally near the tube base deflects the lighter electron beam into the accelerating electrodes, leaving the ions behind in the "trap". It is important to ensure that the small correcting magnet is adjusted for maximum picture brightness before a set is sold or returned to the customer after servicing. Dull pictures and shortened tube life will result from incorrect adjustment of the ion-trap magnet.

Probably the most common cause of tube failure is due to a breakdown in the heater-to-cathode insulation. This defect causes blurred definition and uncontrollable tube illumination with complete loss of picture modulation. Sometimes the tube will function normally after the set has been switched rapidly off and on, but the trouble returns more and more frequently. There are temporary measures for this defect, such as running the tube heater from a floating winding on a separate heater transformer. Some improvement can usually be effected by this measure, but unless the transformer is a specially constructed component with a low inter-winding capacity, most of the video detail at high frequencies will be lost. Grid-to-cathode shorts rarely occur, and are usually accompanied by a "click" from the tube, the screen of which flares brightly as the bias disappears. Very occasionally a tube may show a faulty heater connection which may occur in the base connection. If this condition is suspected, the application of solder and flux may effect a cure. It occasionally happens that the tube E.H.T. connecting cap becomes disconnected and the wire broken off in the glass seal. A satisfactory contact may still be made by means of a quick-

drying, plastic metal compound available from shops dealing with model making.

T. B. S.

TIME-BASE FAULTS

Time-base troubles account for a high proportion of the faults in which the resulting picture appears in a distorted or unsteady form, while faults in the line time-base/E.H.T. circuits are also a common cause of a complete absence of raster. Owing to the divergences in the circuits, similar faults in different time-bases may produce very different symptoms, but the following notes are generally applicable.

Line Time-base Faults

If the line oscillator is not functioning no E.H.T. will be produced, and there will be a complete absence of raster. If it is functioning, but at an incorrect speed, the picture will either not lock and remain a complete jumble (indicating an absence of synchronising pulses) when the line hold control is varied or will lock with several side-by-side images repeated across the screen, indicating that the speed is too fast.

That the oscillator is functioning may be indicated by the presence of the 10-kc/s whistle, but, since this whistle comes mainly from the line output transformer, its absence is not a final test of non-oscillation. With a blocking oscillator a useful check is to measure the voltage with a high-resistance meter between the grid and chassis: oscillation is then indicated by a negative voltage.

Where the speed of a blocking oscillator is too fast, this may be due to failing emission of the valve: high-resistance windings or leaky insulation in the blocking transformer; or a faulty condenser between the " earthy " end of the grid winding and chassis.

Where the speed of a blocking oscillator is too slow, the most likely cause is a resistor increasing in value, usually in the network which feeds the positive bias voltage to the " earthy " side of the grid winding of the blocking transformer.

With multi-vibrator circuits, too fast speed may be caused by low emission of the valves; low capacity or leakage in the grid condensers or change in the networks, if any, supplying the bias to the valve. Too slow a speed is often due to a resistor having gone " high "; suspects should include the anode and screen feed resistors and the grid resistor networks.

Line Output Stage

If the oscillator is functioning but there is a complete absence of raster the fault is almost certainly in the line output stage. First check the three valves: the line output, the efficiency diode and the E.H.T. rectifier. Failure may also be due to a short-

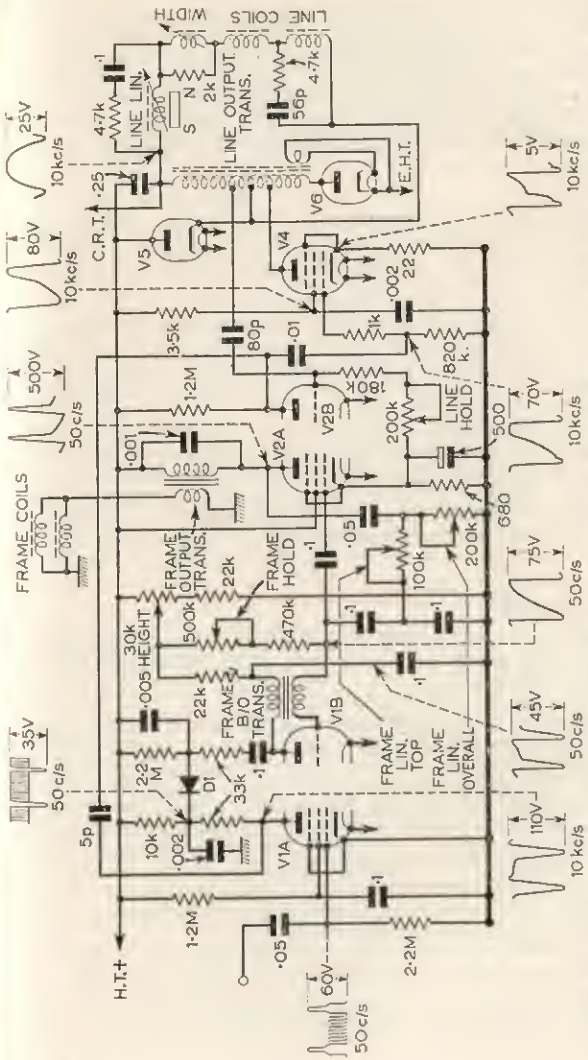


FIG. 5.—THE TIME-BASES OF A TYPICAL MODERN RECEIVER, SHOWING THE WAVEFORMS TO BE EXPECTED AT VARIOUS POINTS. V1A is the sync. separator, and D1 a frame interlace diode. V1B is the frame blocking oscillator, and V2A the frame output valve. V2B forms, with V4, the line multi-vibrator (feedback to V2B via 80pF condenser), V4 being the line output valve. V5 is an efficiency diode, and V6 the E.H.T. rectifier.

F

circuit or "damping" across the output windings of the line output transformer (*e.g.*, shorted turns in the transformer or in the scan coils, or leakage between line and frame scan coils). For some receivers a quick check for damping across the secondary is to unplug the scan coils, but care must be taken to avoid the risk of burning the screen. Also check any screened leads connecting the scanning coils for breakdown of insulation.

Cramping

Cramping on the left-hand side of the picture, with a dark border showing along the mask, may be due to lack of emission in the efficiency diode, or to a high-resistance joint in the wiring to this valve.

Cramping on the right-hand side of the picture is most likely due to failing emission in the line output valve, but may be caused by insufficient power being applied to the heater (for example, due to wrong setting of the mains adjustment panel) or due to the screen feed or cathode bias resistor, if any, having increased in value.

Cramping at the centre of the picture (Test Card "C" showing an "egg-shaped" central circle) may be due to a fault in the cathode circuit (*e.g.*, faulty cathode decoupling condensers) producing negative feedback, or to an incorrect waveform being applied to the output valve, either due to a fault in the oscillator stage or in the correction network in the grid circuit of the output stage.

Frame Time-bases

The absence of frame scan output will result in a thin bright horizontal line across the screen, and when investigating such a fault take care to keep the "brightness" control as low as possible to avoid burning the screen.

A quick check to locate whether the fault is in the oscillator or output stage may be made by touching, as in sound receiver practice, the grid of first the output and then the oscillator valve (take care that the chassis is not at "live" potential). If the valve is working the thin line will open up a little due to hum pick-up. If there is no effect on the thin line it indicates that the valve is not working or that the grid circuit is short-circuited to chassis. Faults likely to produce incorrect speeds, etc., in the frame time-base follow roughly similar lines to those described for the line time-base circuits, although the frequencies involved are much lower (50 frames per second).

If the oscillator is running too fast the picture will appear to be moving downwards; if too slow the direction will appear to be upwards.

Insufficient Height.—Check output and then oscillator valves for low emission, anode feed resistor on the oscillator valve and grid resistor on output valve.

Cramping at Top.—Check the components in the negative feedback correction circuit, if any, between the anode and grid of the output valve. Check the grid coupling condensers for leakage.

Cramping at Bottom.—This may be due to faulty emission of the frame output valve or loss of capacity in the cathode by-pass condenser. Faults in the negative feedback correction components may also give rise to this effect.

Synchronisation Faults

Where the fault is due solely to poor or absent synchronisation pulses it should be possible to obtain a picture momentarily by manual adjustments of the hold controls.

Where it is possible to lock the frame but not the line oscillator, the fault is most likely to be in the differentiating circuit or in any fly-wheel synchronising circuits which may be fitted.

When the line but not the frame oscillator can be locked the fault may be in the integrating circuit or in the interlace filter which may be used to eliminate line pulses from the frame synchronising pulses.

Poor hold on both oscillators may be due to the synchronising separator valve failing, incorrect screen voltage due to feed resistor increasing in value or leakage in the by-pass condenser.

If the line hold only is weak examine the line synchronising feed condenser. Where line tearing is pronounced, it may be due to the coupling components in the grid circuit.

LINE OUTPUT TRANSFORMERS

The line output transformers in modern receivers are subjected to severe voltage and current stresses, and it is not surprising that these occasionally fail. However, it is sometimes too quickly assumed that any failure in the line scan or E.H.T. circuits, if not caused by valve failure, must be due to the output transformer. Many of the output transformers which are returned to manufacturers as "faulty" are subsequently found to be in good order. The following notes, based on information prepared by Alfred Rose, M.I.R.E., of *Direct TV Replacements*, offer useful guidance on this subject.

The following are some of the faults which may induce symptoms similar to those of a faulty line output transformer:

(*a*) Deflector coils with shorting turns, open-circuit winding or leakage between windings, or from winding to core.

(*b*) E.H.T. rectifier valve having gone "soft" or having an interelectrode short-circuit.

(*c*) Leakage due to incorrect routeing of wiring to the output transformer.

(*d*) Short-circuited line linearity trimmer (a fault very often overlooked) or a short-circuit in the associated components.

(*e*) Corona occurring at the anode cap of the picture tube, or at the connecting wires to the E.H.T. rectifier.
(*f*) The picture tube taking excessive E.H.T. current.
(*g*) Incorrect line speed.
(*h*) Faulty biasing on the line output valve.
(*i*) Faulty width coils.
(*j*) Faulty efficiency diode.

The following are some suggestions for tests which can be carried out on suspected output transformers, particularly where these are fairly new or recently rewound:

(1) Make a careful visual examination. For example, when wiring a transformer into the set, the heat of the soldering-iron may easily release fine wires coming from the windings.

(2) Check the tappings carefully to ensure that both wires are connected to the tag.

(3) Check that solder has not been dropped on to a winding and so causing short-circuited turns.

(4) Check that the windings have not been knocked, or that the windings have not been damaged by a slipping screw-driver.

(5) Listen for the 10-kc/s whistle: if this is present but there is no E.H.T., suspect the heater circuit of the E.H.T. rectifier. A useful test is to disconnect the rectifier heater winding and connect the E.H.T. rectifier to a well-insulated battery. Should E.H.T. then appear, examine the picture and watch the effect of connecting one side of the heater winding to the rectifier (note this will be at E.H.T.). If corona then appears, or the picture fades away, the most likely cause is poor heater-winding insulation. Should the picture not be affected by connecting the heater winding, the most probable fault is insufficient drive. Where heater insulation leakage has been confirmed, it is possible, in certain cases, for example, where a U25 valve is concerned, to obtain a small heater-isolated transformer; this will avoid replacing the output transformer. *Warning:* Do not touch the battery when making the above test, as its case will be at E.H.T.

(6) Check the transformer under working conditions in a darkened room, as corona and arcing can be detected most easily in this way. Corona is usually caused by sharp points on soldered joints or sharp wire ends.

(7) Always check that the correct type of rectifier valve has been fitted.

(8) Remember that the D.C. resistances listed in service information are intended as a rough guide only. Actual values may differ appreciably on each batch of windings. Then, again, some manufacturers have substituted different gauge wire in replacement transformers, for example, a heavier gauge wire with less D.C. resistance may be used to prevent overheating. It may also be found that the resistance of the E.H.T. overwind is very much greater than that specified. This may be due to the use of resistance wire in order to overcome striations (such a winding may be about 4,000 ohms instead of the 200 ohms specified in the original data).

(9) Where the E.H.T. increases greatly when the anode cap is removed from the picture tube, suspect that either the tube is drawing excessive current or that the rectifier valve is faulty.

(10) Many line output transformers are damaged by overload due to the line drive control, if fitted, being wrongly adjusted, particularly after the replacement of a line output valve. If a white vertical line appears at the left-hand side of the screen check that this control has been correctly set. Do not correct the fault merely by altering the width control unless it has already been confirmed that the circuit is working correctly.

TURRET REPAIRS

The repair of faulty turret tuners often requires most delicate workmanship, and less skilled work is likely to impair rather than to improve results. It is for this reason that many manufacturers recommend that turrets should always be returned to them for repair or adjustment.

For instance, the adjustment of the band-pass transformer coils between the R.F. amplifier and the mixer is generally considered most inadvisable, as this operation really requires laboratory-type alignment equipment. Even the adjustment of the oscillator and aerial coils should be tackled with care.

The most frequent fault in turret tuners is oxidisation of the stud contacts, resulting in noisy or intermittent reception on one or more channels. The studs are readily accessible by removing the turret cover. Conventional switch-cleaning fluids, such as carbon tetrachloride, will remove the oxidisation but do not provide any protection against the fault reoccurring and, unless used extremely sparingly and carefully, may attack the turret materials. A safer method of removing oxidisation is to polish the studs with a dry cloth. The channel-selector mechanism on turrets should be kept lubricated, and after cleaning it is advisable to apply a smear of petroleum jelly to each stator spring contact. There are also available protective lubricants, such as " M.S.4 " and " Electrolube ", containing water-repellent substances, and these provide useful protection against oxidisation.

It is important that no attempt be made to increase contact pressure indiscriminately by adjustment of the spring contacts, although sometimes adjustment to the switch-locating device will change the point of contact slightly. The contact pressure should be adjusted only where there is clearly a loose spring.

A common cause of short-circuits is the wearing off of the insulating paint on the ends of the small ceramic capacitors, leaving an exposed wire which may rub against another component. Faulty components may be the result of overheating during soldering, either in manufacture or subsequently.

Where any attempt is made to replace a component, it is essential that the tuner should be handled with great care, and that only an exact replacement, physically as well as electrically, should be fitted in the precise position of the original component, with connecting wires of the same length and path.

Coils are often adjusted by spreading their ends; great care should be taken not to disturb them accidentally.

TROUBLE TRACING CHART

Although the limitations of a simplified chart should be recognised, the following list of common symptoms and possible causes will provide useful guidance, particularly for the radio service engineer who has had relatively little practical experience of television work.

Owing to divergences in circuit technique, symptoms of a particular fault may vary considerably, but the following summarised information is applicable to most modern receivers.

MISCELLANEOUS PICTURE FAULTS

While many picture faults provide by their symptoms an obvious clue as to the source of the trouble—linearity faults, such as cramping, insufficient height or width, for example, immediately suggest a time-base fault—there are a number of symptoms for which the location of the trouble will prove puzzling to the newcomer to television servicing, but which, once recognised, provide no less valuable a clue as to the likely fault.

"Ringing"

This common picture fault, which takes the form of a black line immediately to the right of a white object, or a black line following a white object, is almost invariably caused by a distorted vision-response curve, providing excessive H.F. amplification. Response characteristics of this type tend to produce a series of damped oscillations in the tuned circuits, and these produce the effect already described. Where the fault is found when installing a new receiver, it often denotes mistuning of the local oscillator, while on older receivers it may either be due to local oscillator drift or to misalignment generally. However, where the fault develops suddenly and is accompanied by a marked reduction in the band-width of the receiver (as shown on Test Card C) and an increase in sensitivity, the damping resistors across the tuned circuits should be checked. Faulty components in the video compensating network of the video output stage, and the decoupling circuits, are other frequent causes of "ringing", a useful pointer in this case being that the receiver sensitivity may not be unduly affected. It should be noted that in some receivers, particularly those intended for "fringe" reception, a certain degree of "ringing" may be introduced intentionally to sharpen the images; but since it is difficult to prevent such

Symptoms	*Possible Causes*	*Check*
Blank screen (no sound)	Mains lead, fuses, "on-off" switch	That mains supplies are reaching set
	Mains voltage adjustment resistors and sockets	Continuity
	Heater chain fault	Valves, cathode-ray tube, thermistor, dropping resistors for o/c
Blank screen (sound working)	Heater chain fault (s/c to chassis above cathode-ray tube)	Cathode-ray tube heater glow
	No E.H.T.	Line output efficiency diode E.H.T. rectifier and line oscillator valves
		Line time-base voltages. (Note: Never attempt to measure the voltage directly at the anode of the line-output valve, as the E.H.T. pulses will damage the meter.)
		Line output transformer
		Line time-base components
		Cathode-ray tube for ionisation (try effect of removing E.H.T. connection)
		Note: When testing for E.H.T. with well insulated screwdriver: (1) continuous blue arc denotes pulse (A.C.) voltages; (2) "brushing" (finer crackling sparks) denotes D.C.
	Ion trap misplaced	Fibre mounting is not loose or broken
	Overbiasing of cathode-ray tube	Cathode and grid voltages on cathode-ray tube
		Components in brightness control network
		Video amplifier valve for inter-electrode s/c
		Components in video amplifier stage
	Absence of cathode-ray tube 1st anode voltage	Voltage
Blank raster (sound working)	Faulty vision receiver	I.F. valves, video amplifier valves and voltages

Symptoms	*Possible Causes*	*Check*
Blank raster (no sound)	Faulty tuner unit Faulty common I.F. stage Faulty aerial	Valves and voltages Valve(s) and voltages Co-axial socket connections and feeder
Uncontrollable brilliance	Cathode-ray tube fault Incorrect biasing	For interelectrode s/c or leakage Brightness control network Video amplifier valve and voltages Video detector diode
	Instability in vision receiver	Aerial connections Screening cans Decoupling condensers
Picture size varies with brightness control setting	Poor E.H.T. regulation	E.H.T. rectifier for low emission Line output and efficiency diode valves Line output transformer
Picture displaced	Incorrect centring Displaced scan coils or focus magnets Displaced ion trap	Adjustment of centring magnets Positioning Setting
Picture sizes varies with loud sound passages	Microphonic valves in line time-base	Valves by gently tapping
Picture reversed	Deflector coil connections reversed	Connections
Poor focusing	Ion trap or steering magnet displaced or misadjusted	Setting
	E.H.T. low	E.H.T. system Mains voltage adjustment setting
	Cathode-ray tube low emission Incorrect 1st anode voltage of tetrode cathode-ray tube	Tube by substitution Voltage

Symptoms	*Possible Causes*	*Check*
Poor focusing (*contd.*)	Incorrect focusing voltage of electrostatic cathode-ray tube	Alternative voltage settings
Bright horizontal line (no picture)	Faulty frame time-base Faulty frame deflection coils	Valves, voltages and components Coils and connections
Insufficient picture height	Low output from frame time-base Partial s/c frame deflection coils High E.H.T. Picture displaced downwards	Valves, voltages and components Coils for shorted turn E.H.T. system Centring
Bright vertical line (no picture)	Line deflection coils	Coils for o/c Connections to coils
Insufficient picture width	Incorrect setting of mains voltage adjustment Faulty line output stage	Check setting against supply voltage Line output valve and efficiency diode for low emission Valve voltages Line output transformer
	Low H.T.	Mains voltage adjustment H.T. rectifier
	Faulty line deflection coils	Coils for shorted turns
Cramping at top or bottom of picture	Frame time-base non-linear	Linearity control Frame time-base valves Frame time-base linearity network components
Excessive width or height (picture dim)	Low E.H.T.	E.H.T. system Cathode-ray tube for ionisation

Symptoms	*Possible Causes*	*Check*
Picture distortion	Incorrect adjustment of linearity controls	Setting
	Faulty time-bases	Valves, voltages Linearity correction components and networks
	Displaced or defective deflection coils	Coils and positioning
	Cathode-ray tube distortion and/or correction magnets	Positioning
	Moisture on cathode-ray tube bulb Bulb charge on cathode-ray tube	Clean and dry screen and implosion guard.
Negative picture	Displacement of ion trap	Setting
	Low cathode-ray tube heater voltage	Voltage or current
	Low cathode-ray tube emission	Tube by substitution
	Overloading of video detector or video amplifier	Aerial attenuator
Dark band across picture	50 c/s hum	Smoothing components Valves for heater/cathode leakage
Sound-on-vision	Oscillator incorrectly tuned	Setting of fine tuner (Band I/III sets) Tuning of oscillator core (Band I sets)
	Overloaded valves in vision receiver	Effect of reducing signal input (aerial attenuator)
	Valve or cathode-ray tube microphony	Effect of reducing volume. Trace faulty valve by tapping gently
	Sound trap(s) or bridged-T filter misaligned	Alignment
	Feedback in H.T. circuits	Decoupling condensers
Vision-on-sound (denoted by presence of frame sync. buzz)	Overloaded valves in receiver circuits	Effect of reducing signal input (aerial attenuator)
	Oscillator incorrectly tuned	Setting of fine tuner or oscillator core
	Feedback in H.T. circuits	Decoupling condensers (particularly for frame output valve)
	Misalignment	Alignment

Symptoms	*Possible Causes*	*Check*
Brushing (feathery band of interference on left of picture)	Corona discharge	E.H.T. rectifier and circuit, gun lead and cap to cathode-ray tube for discharge in darkened room. (Remove solder " spikes " and/or apply silicone jelly.)
	Faulty line output transformer	Insulation
Ringing (black line immediately following white object, and vice versa)	Distorted vision response curve	" Quality control " setting (if fitted) Oscillator setting and alignment Video compensating network
Line Ringing (vertical striations on left-hand side)	Damped oscillations in scanning circuits	Anti-striation trimmer setting (if fitted) Damping resistors across width control Damping resistors across deflection coils (old models)
	Spurious oscillation in line time-base	Line output valve
	Local Interference	Local Band III converters and time-bases for radiation
Poor definition (lack of highlights)	Lack of signal strength	Aerial installation for damage to elements, water in tubular elements, incorrect orientation, fault in feeder, etc.
	Lack of video signal	Tuner and I.F. valves and alignment, video amplifier valve
	Low receiver voltages	Mains voltage adjustment setting
	Interference limiter over-advanced	Setting
	Low voltage on 1st anode of cathode-ray tube	Voltage and boost line
	Low emission of cathode-ray tube	Tube voltages and try substitute tube
	Heater/cathode leakage on cathode-ray tube	Insulation
	Ion trap mis-set	Setting

instability from later becoming more pronounced, designers must be wary of carrying this process too far. An effect somewhat akin to "ringing" may also be caused by "ghost" images (see page 142) produced by the arrival of signals at the receiver along multiple paths.

"Line Ringing"

Vertical bars on the left-hand side of the picture may be caused by "ringing", *i.e.*, damped oscillation, of the scanning coils or line-output transformer. With improvements in the efficiency of these components and the use of efficiency and boost diodes, this fault has become less frequent; but in older models it is not uncommon for the high-wattage damping resistor (which is required to dissipate considerable energy) connected across the scanning coils to become open-circuited. On some modern receivers employing wide-angle tubes, a somewhat similar symptom may be caused by spurious signals from the line-output valve beating with the local oscillator to produce an interfering signal; the remedy is to provide a small high-voltage decoupling capacitance to the anode of the line-output valve.

Sound-on-vision

Alternate light and dark horizontal bars across the picture, occurring during the louder sound passages, and sometimes when severe destroying line hold, are the symptoms of this fault. The intermittent nature of the trouble will distinguish it from the effect of hum in the receiver. The fault may be due to misalignment, general inefficiency of the sound-rejector circuits, or simply to slight oscillator drift which may be insufficient to produce other harmful effects. Another common cause—though one that is not likely to arise after the receiver has been working successfully—is overloading of the frequency changer valve, and this may be cured by fitting an attenuator pad in the aerial feeder. Other possible causes are valve microphony and feedback in the H.T. circuits.

"Pulling"

"Pulling on Whites" is the name given to a fault in which the picture is momentarily displaced horizontally whenever a white image moves across the right-hand side of the picture: it can most clearly be observed on Test Card C, when a castellated effect on vertical lines will be found to coincide with the changes from black to white in the right-hand border. It is caused by later triggering of the line-scan oscillator following a line ending in white light, due to the receiver not responding to the "front porch" preceding the line pulse. This may be due to poor high-frequency response of the vision receiver, and in this case will be accompanied by loss of the high definition patterns, or, where the patterns are unaffected, by loss of high frequencies in the circuits immediately preceding the synchronising separator; a likely

cause being high stray capacitance in the coupling between the video amplifier and the grid of the synchronising separator.

"Pulling on Blacks", or as it is sometimes called "triggering on picture", is a somewhat similar condition, but with the picture displaced in the opposite direction. The cause is almost invariably incorrect clipping in the synchronising separator; the clipping being above the 30 per cent black level, and thus allowing picture content to trigger off the time-bases. A faulty component in the synchronising separator stage, such as an increase in value of the screen-feed resistor, is usually the reason for this condition.

"Plastic" Picture

Where the outlines of objects are clear but the picture has an overall grey appearance, the usual cause is poor L.F. response in the vision receiver or video amplifier, and any of the components or adjustments affecting overall response may be at fault; these include misalignment or incorrect local oscillator setting; a decrease in value of a coupling or by-pass condenser in the video amplifier.

"Flare" or "Streaking"

These terms are used to describe the condition when streaks or smudges appear to follow black-and-white images horizontally across the screen: the black horizontal bar at the top of Test Card C provides a most useful check. The cause is excessive L.F. response, which here again may be caused by misalignment or defective compensation in the video-amplifier stage. A gradual increase in flaring usually suggests misalignment or oscillator drift, whereas any sudden increase points to a faulty component, such as a decoupling condenser, or an increase in value of the anode-load resistor in the video amplifier.

Loss of Highlights

A condition may sometimes be encountered where the darker shades of the picture are reproduced normally, but the lighter tones tend to flatten out and become almost indistinguishable from one another. This is caused by the peak amplitudes of the vision signals being lost by clipping, and is commonly caused by over-advance of the vision-interference limiter, but may also be due to overdriving the cathode-ray tube or incorrect bias in the video-amplifier stage.

[SECTION 13]

ALIGNMENT

by D. H. Fisher, A.M.I.E.E.

Television demands the transmission of information covering a wide band of frequencies if the picture is to be accurately reproduced. In the case of the British 405-line system the highest signal frequencies are approximately 3 Mc/s, and if the transmitter is modulated in the normal manner sidebands will extend to

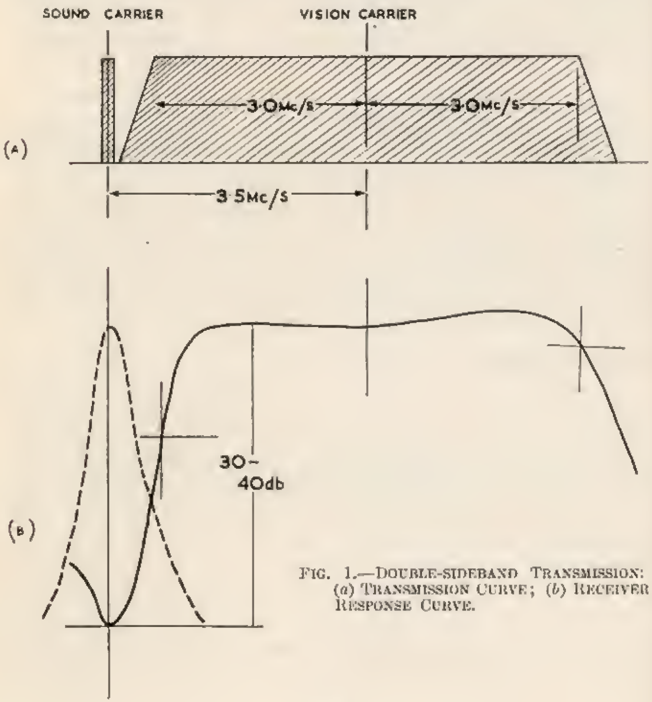


Fig. 1.—Double-sideband Transmission: (*a*) Transmission Curve; (*b*) Receiver Response Curve.

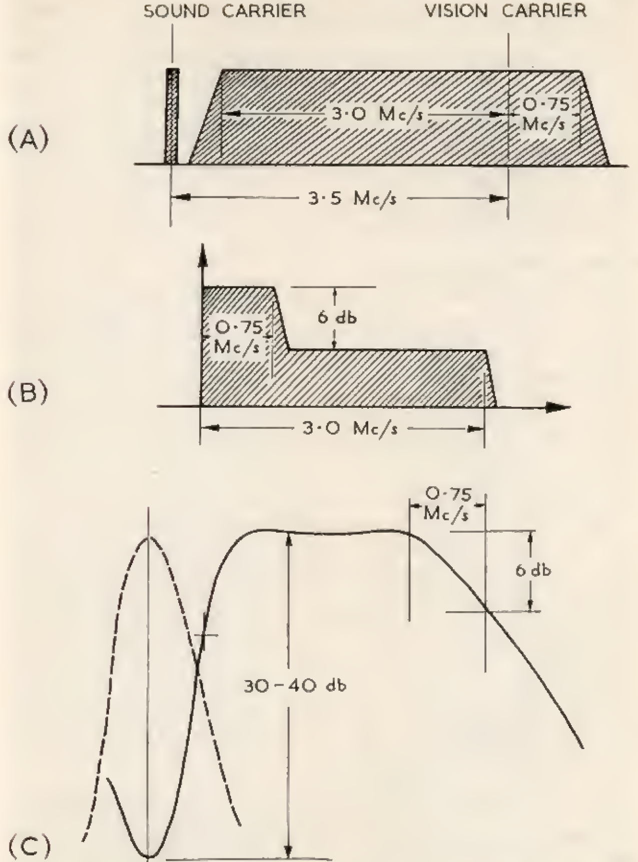


Fig. 2.—Vestigial Sideband Transmission: (*a*) Transmission Curve; (*b*) Response Curve at Detector; (*c*) Modified Response Curve at Detector.

± 3 Mc/s about the carrier. The double-sideband transmission curve is shown in Fig. 1 (*a*).

At the inception of the British television service the first station, Alexandra Palace, operated in this way, but the requirements of a national service including several transmitters made it necessary to use the available frequency band more efficiently.

Accordingly, vestigial sideband transmission has been utilised for all other stations.

It is by no means necessary to transmit both sidebands in both sound broadcasting and television, provided that proper precautions are taken. In the former it would probably be very inconvenient to depart from standard double-sideband practice, but in the latter the saving effected is very important. Rather severe difficulties would arise if one sideband were completely removed, particularly with a high-power transmitter, and as a result a "vestige" is allowed to remain. Fig. 2 (*a*) shows the transmission curve for this system.

Receiver Response Curves

The television receiver must, in the amplifier stages before and after the detector, produce equal gain over as much of the frequency band as possible. The response curve of a double-sideband receiver will, therefore, be of the nature shown in Fig. 1 (*b*). Care is taken to keep a level response within the passband and to achieve the greatest possible attenuation at the sound carrier (sound rejection). This requirement conflicts with the need to reproduce the extreme lower sideband frequencies, and the response normally falls off between 2·0 and 2·75 Mc/s. A very sharp fall off at the edge of the passband should be avoided, or high-frequency distortions—"rings"—will occur.

In vestigial sideband transmission some arrangement must be made for the fact that both sidebands are present up to 0·75 Mc/s. In other words, double the energy is present, and if received without modification the rectified video information at the detector will appear as shown in Fig. 2 (*b*). The output up to 0·75 Mc/s will be 6 db, or 2 to 1 higher than the H.F. components. This may be overcome by letting the response fall off at a steady rate from 0·75 Mc/s below to 0·75 Mc/s above the vision carrier. The fall-off rate should be 8 db/Mc/s, the carrier, therefore, being 6 db down from the top of the response curve as in Fig. 2 (c). Alternatively, the carrier is placed at, say, 2 db down, and the video amplifier response curve is raised by 4 db at frequencies above 0·75 Mc/s.

The sound-channel responses are also shown on the diagram. Bandwidths of $\pm 0{\cdot}5$ Mc/s are quite common for television sound channels. In the first place this helps in the problem of oscillator drift in superheterodyne receivers and generally makes the circuit non-critical. Second, impulsive interference is more easily dealt with when amplified by a wide-band channel producing sharp pulses of a less objectionable nature. The sound channel must be well down at the vision-carrier frequency, where L.F. vision components would produce heavy interference.

Forming the Response Curve

The fairly strict requirements of the response curve can be satisfied in several ways. T.R.F. receivers using several stages

were often designed on the staggered-tuning principle (superheterodynes as well, although, having rather less stages in the I.F. amplifier, more complex circuits are sometimes needed).

The staggered-tuning principle consists of having a single circuit between each valve and adjusting its Q and tuning point to form a suitable combination with all the others. Fig. 3 (*a*) shows a five-circuit arrangement called a quintuplet. Trap or "sucker circuits" have been added to achieve extra attenuation at the sound frequency. Traps T1 and T3 couple with L2 and L4 respectively to form a combined response curve in each case. T2 is in the cathode circuit of V3, and serves to lower the gain at the trap frequency.

The second part of Fig. 3 shows how L1, L4 and L5 combine to give an approximate response curve, and L2 and L3 sharpen the edges. Sound is taken from the junction of T1 and L2. T1, however, is not exactly tuned to sound frequency due to its reaction with L2, and the sound is coupled very lightly into L6 so that interaction shall not occur.

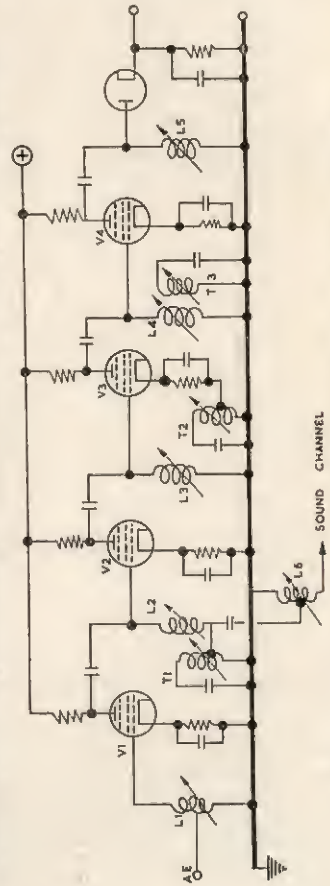


Fig. 3 (*a*).—Typical T.R.F. Five-circuit Arrangement Using Staggered Tuning.

Fig. 4 (*a*) shows a two-valve amplifier suitable for a superheterodyne. The coupling between the mixer and V2, and V2 and V3 is by means of two circuit filters or bandpass circuits. The first uses mutual inductance coupling with a trap and sound take-off similar to the previous circuit. The second uses top capacity coupling, and a trap has been added. Looking at the lower part of the diagram, it can be seen that the combination of L3, L4 and L5 produces nearly the required curve, which

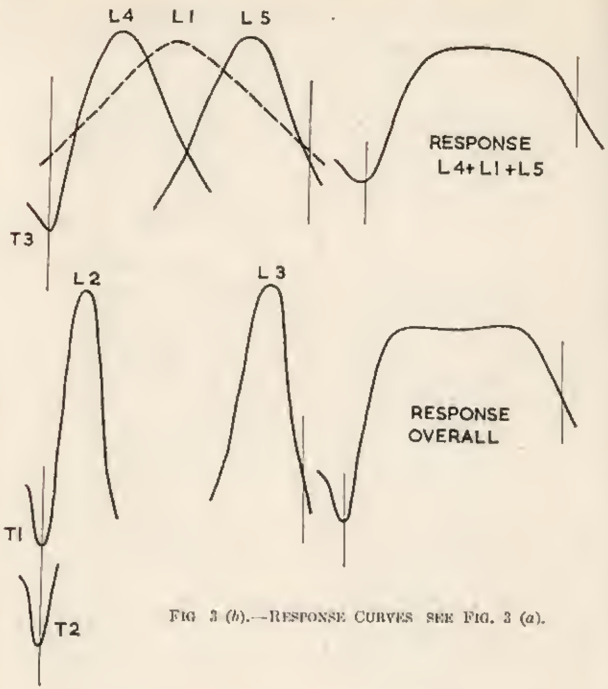
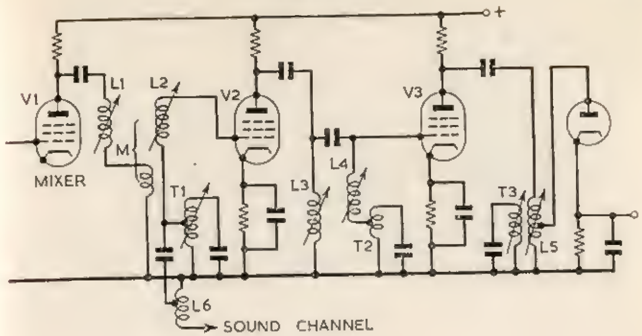


Fig. 3 (*b*).—Response Curves see Fig. 3 (*a*).

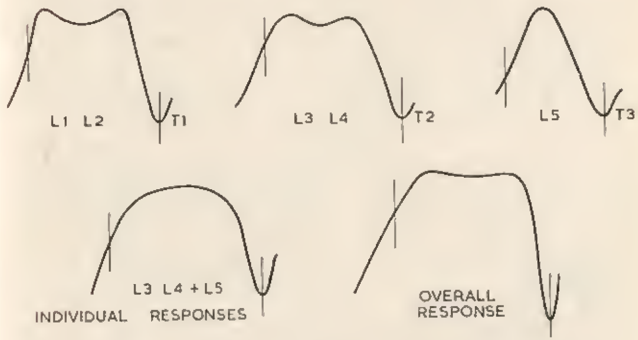
is sharpened at the edges by L1, L2 as we saw in the previous arrangement.

Pre-mixer Circuits

In a superheterodyne receiver the precise response curve required is always obtained in the I.F. circuits. The purpose of the pre-mixer circuits is to preserve this response and provide extra attenuation outside the passband so that I.F. breakthrough, second-channel (or "image") or adjacent-channel interference do not occur. The gain before the mixer must be sufficient to render the large amount of noise generated by the mixer negligible compared to the signal at its grid when operating at full sensitivity.



(a)



(b)

Fig. 4.—Circuit and Response Curves, Two-valve I.F. Amplifier.

BAND I/III RECEIVER CIRCUITS

The I.F. Amplifier

Fig. 5 (*a*) shows the complete circuit of the R.F. and I.F. stages of a receiver including a turret tuner. Although it is an economic design, the response curve is to a higher specification that the circuits previously described and one of the bandpass couplings is complex.

The operation of the circuit is, briefly, as follows: IFT V3 is an over-coupled transformer providing a simple double humped curve as shown in Fig. 5 (*b*). Almost the entire overall curve shape is determined by the network between V3 anode and V4

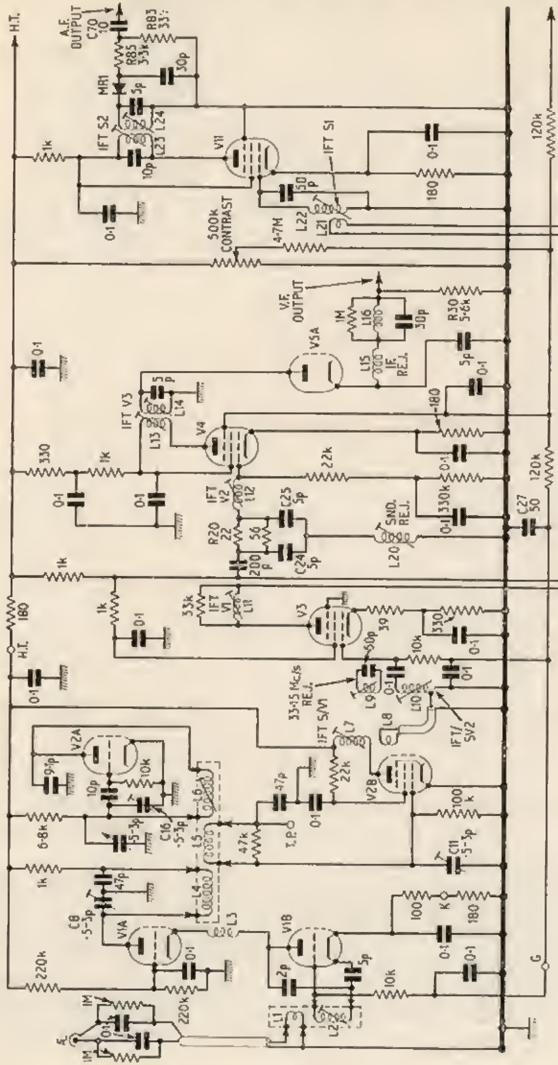


FIG. 5 (a).—CIRCUIT DIAGRAM OF THE TUNER UNIT AND I.F. STAGES OF AN R.G.D. BAND I/III MODEL.

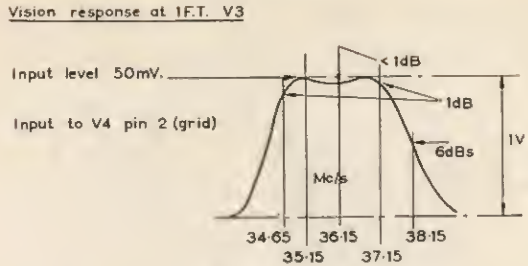


FIG. 5 (b).

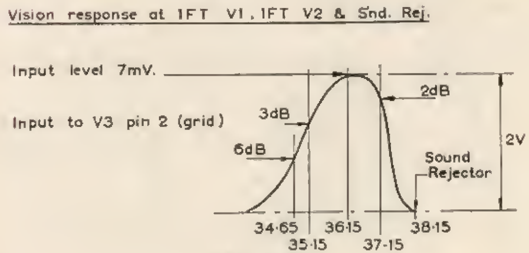


FIG. 5 (c).

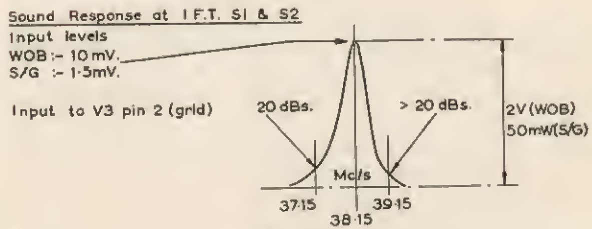


FIG. 5 (d).

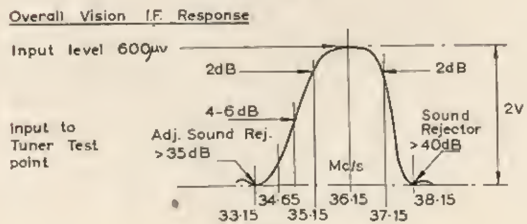


FIG. 5 (e).

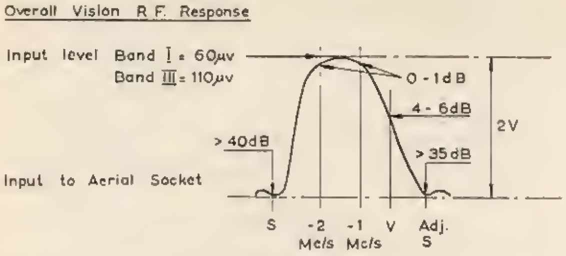


FIG. 5 (*f*).

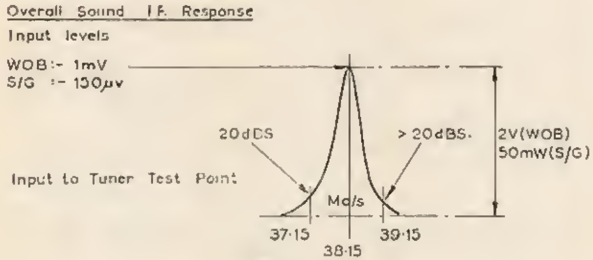


FIG. 5 (*g*).

grid and consisting of IFT V1 (L11), L20 and IFT V2 (L12). L11 and L12 are a bandpass pair, bottom coupled by L20, which is bridged by C24, C25 and R20. This is known as a " bridged T " coupling, where L20, C24 and C25 are resonated at the sound frequency to produce a high degree of rejection by reducing the coupling between L11 and L12. R20 is a balancing resistor which is chosen during design for optimum rejection with the minimum effect upon the vision response curve. The overall curve from V3 grid is shown in Fig. 5 (*c*) and the sharpness of rejection is apparent. It is also seen that the overall shape is rounded. This shape is now being used by designers in an attempt to overcome picture distortions such as rings and overshoots which arise with flat-topped curves.

The connection between L11 and the " bridged T " filter passes through the primary of IFT S1. There is a considerable amount of sound-frequency energy available at the input of the filter, due to its resonance, and in this way it may be passed to the sound amplifier V11. The output of V11 is coupled to the sound detector via IFT S2, and the overall sound curve from V3 grid is shown in Fig. 5 (*d*).

The circuit coupling the mixer in the tuner is a broad one, since it has to transfer both vision and sound. Also, the tuner being a separate unit, the circuits IFT SV1 (L7) and IFT SV2

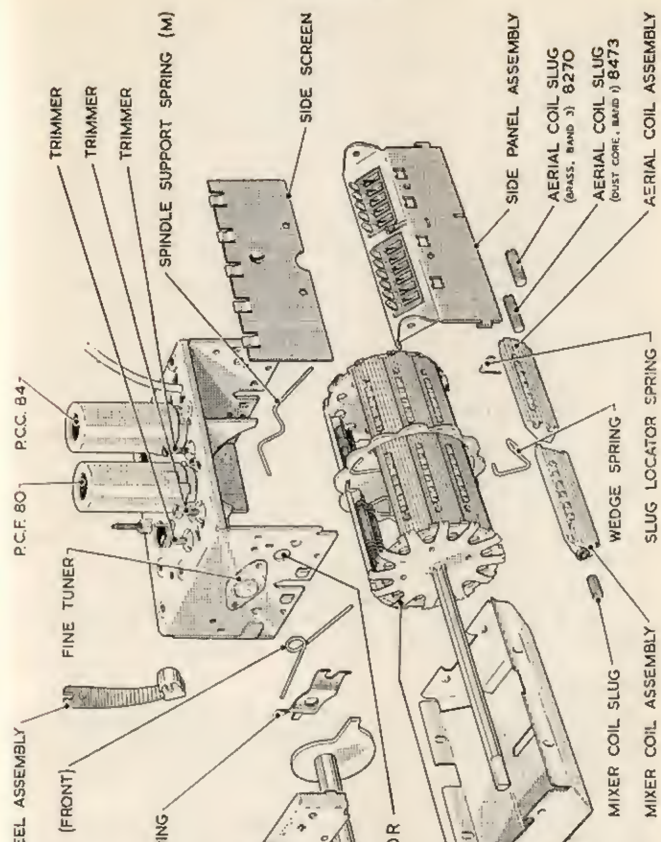


FIG. 6.—CONSTRUCTIONAL DETAILS OF THE TURRET TUNER IN FIG. 5 (*a*).
(*Sydney S. Bird and Sons, Ltd.*)

(L10) are coupled via a cable link. L9 is a trap circuit coupled inductively to L10 to produce a rejection at the I.F. produced by sound frequency interference from the next channel. The type of response given by this network is broad and flat except for the rejection due to L9. The overall response at the grid of V2 (tuner test point) is given in Fig. 5 (*c*).

The Turret Tuner

In the tuner (see Fig. 5 (*a*)), L4, L5 form a bandpass at signal frequency between V1A anode and the mixer (V2B) grid. The response is again broad to transfer vision and sound without affecting the overall I.F. curve.

L6 is the oscillator coil appropriate to each channel, the oscillator voltage being fed into L5 by mutual coupling between the coils. L6 has a screw core adjustment.

L1, L2 is the aerial circuit, a coupled transformer, forming with the response of L4, L5 an overall flat curve for the tuner. The overall curve for the set is shown in Fig. 5 (*f*).

It is essential for the aerial circuit to be tuned correctly to the centre of the band for maximum gain and lowest noise on the picture (especially where signals are weak). L1, L6 are the only adjustments normally available in a turret tuner. The coils are built on to removable plastic " biscuits ", and the inner coils L4, L5 are set up and sealed in manufacture. Fig. 6 shows the construction of a typical tuner, and " biscuit ". The hole through which L6 may be tuned is clearly indicated: L1 may be reached through an identical hole at the rear.

All other adjustments in the tuner are for manufacturing set up only, and should *not* be used unless a complete alignment is being attempted.

The Switch Tuner

A switch-type tuner can equally well be used, and the circuit of one is shown in Fig. 7. Here, instead of having the aerial and oscillator circuits of each channel to tune when set to a given channel, all the oscillator circuits are available through the front (see Fig. 8).

The aerial, R.F. anode and mixer-grid circuits have screw adjustments only for Band III as a whole and Band I as a whole.

Because all the circuits are in series, alignment of any circuit must be done by working down from Channel 13, one channel at a time. If, however, only one channel is in use in each band, it is permissible to use the adjustments appropriate to the whole bands only, *i.e.*,

Band	*Aerial*	*R.F. Anode*	*Mixer Grid*	*Oscillator*
Band III	L9	L11	L27	L37
Band I	L7	L13	L22	L35

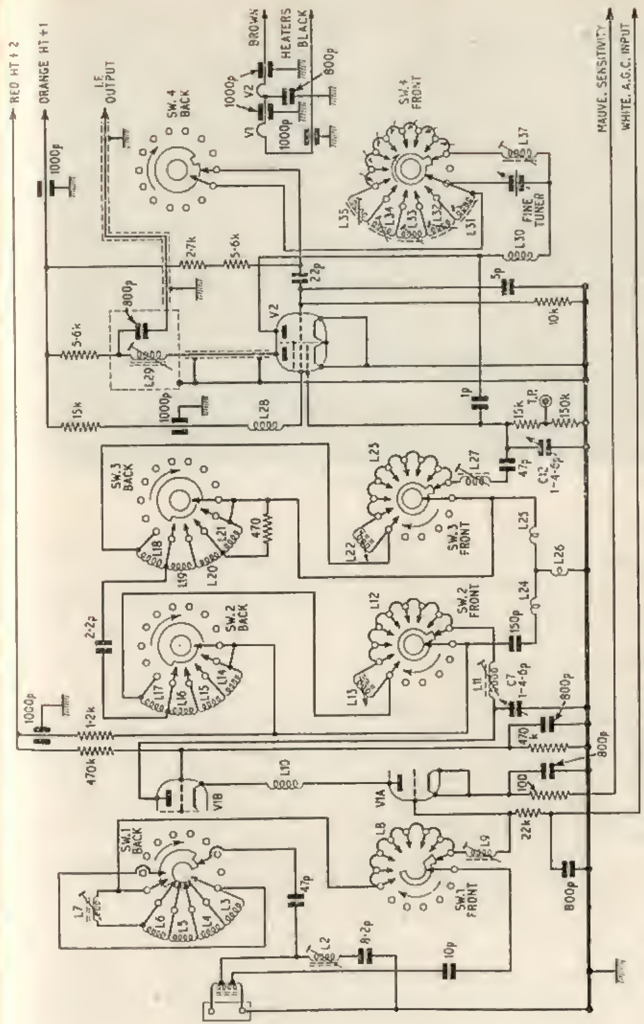


FIG. 7.—CIRCUIT DIAGRAM OF A TYPICAL INCREMENTAL SWITCH BAND I/III TUNER UNIT.

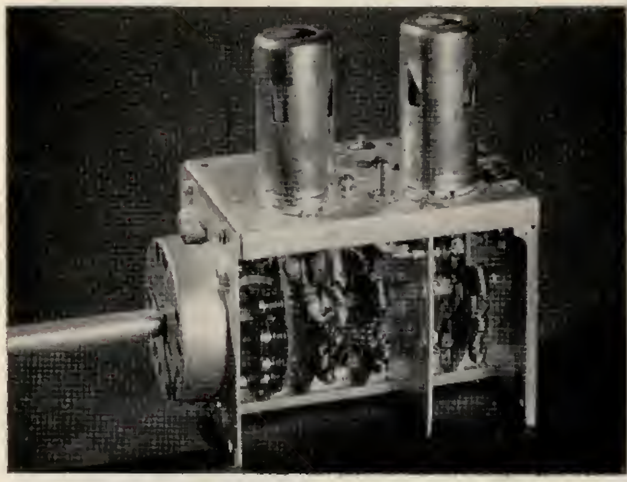


FIG. 8.—INCREMENTAL SWITCH BAND I/III TUNER.
(*Pye, Ltd.*)

Normally only the oscillator circuit should be considered and the adjustment for the appropriate channel tried first.

The aerial circuit can well be trimmed after valve changing. The makers' instructions alone should be followed when attempting complete realignment.

Intermediate Frequencies

The first superheterodyne receivers used intermediate frequencies near 10·5 Mc/s for vision and 14·0 Mc/s for sound. Interference problems proved serious, and a movement was made to 16·0 Mc/s vision and 19·5 Mc/s for sound. Difficulties also arose with these frequencies for sets tuning to Band III in that the "image" was too close for good rejection and oscillator radiation was often high. Finally, B.R.E.M.A. set a standard of 34·65 Mc/s for vision and 38·15 Mc/s for sound.

It is essential that I.F. amplifiers are aligned accurately to the frequencies specified, otherwise interference problems and difficulty in aligning the tuner may result.

A.G.C.

Automatic Gain Control circuits are now used on sound and vision circuits. The sound A.G.C. is often simple and consists of a connection via a smoothing circuit between the detector output and I.F. valve(s) grid returns. The vision A.G.C. may

be more complicated and the R.F. stage may have the A.G.C. voltage delayed. Makers' instructions should always be followed when aligning sets with A.G.C. When in doubt, apply −2V approximately to the vision A.G.C.: short-circuit sound A.G.C. and R.F. stage A.G.C. only when delayed.

ALIGNMENT PROCEDURES

Signal-generator Alignment, Band I Models

Test gear requirements are detailed in Table 13.1 :

TABLE 13.1

Item	*Remarks*
Signal generator . . .	Should be the most reliable instrument that can be afforded. Frequency range 10–220 Mc/s. Output-level indicator and calibrated attenuator important. Leakage must be negligible.
Output indicator .	Universal meter 20,000 ohms per volt (not less) satisfactory. Alternatively 100 μA f.s.d. meter in series with 50 kilohms (reading 5 V full scale).
Connectors and damper .	See Fig. 9.

The individual steps to be followed in the alignment of the two circuit arrangements shown in Figs. 3 and 4 are set down in Tables 13.2 and 13.3. The routine followed in each case is the same, although tuning the bandpass circuits is a little more difficult than a simple tuned circuit. Basically, the output indicator is attached to the detector load, and each stage is aligned individually, working back from output to input. At each step it is necessary to reduce the signal-generator input to keep the output level the same. The output level should be limited to, say, 2 volts, although various manufacturers may suggest different levels, depending upon the design. They may direct the output reading to be taken from the output of the video amplifier; otherwise, especially in cases of doubt, the detector load should be used.

Where instability is suspected it is a good plan to connect an oscilloscope across the meter. The noise level will seem to rise if instability commences, or, if the signal generator is modulated, distortion of the waveform may take place.

In Table 13.2 it has been assumed that the set is a T.R.F. for the London channel. Each tuned circuit is tuned to a certain frequency; this information is normally given by the maker, and varies from model to model. The figures in the table are more or less what might be found in a set of this type, but are for the purposes of example only. It is very important in most cases to tune the trap circuits before the accompanying signal circuit. If this procedure is not followed, interaction will occur and the alignment will have to be repeated.

TABLE 13.2.—ALIGNMENT OF STAGGER-TUNED T.R.F. RECEIVER

Step	*Connect Meter To:*	*Connect Signal-generator To:*	*Tune Circuit:*	*To:*	*At (Mc/s)*	*Remarks*
1	Vision det.	Grid V4	L5	Max.	44·0	
2	,,	Grid V3	T3	Min.	41·5	High input level
3	,,	,,	L4	Max.	42·5	
4	,,	Grid V2	T2	Min.	41·5	High input level
5	,,	,,	L3	Max.	44·25	
6	,,	Grid V1	T1	Min.	41·5	High input level
7	,,	,,	L2	Max.	42·25	Reduced gain setting may be used
8	,,	AE socket *	L1	Max.	43·25	
9	,,	,,	Check sensitivity and response curve by slowly moving signal generator across band			
			Check input at 41·5 Mc/s for same output reading to evaluate sound-rejection figure			
10	Sound det.		L6 and sound circuits	Max.	41·5	

Other Remarks: If the finished response curve slopes gently up or down as the frequency is increased, a slight alteration to the centre circuit L1 may correct this tendency. The response curve may be allowed to have a slight hump or dip at the centre; this should be less than 1 db if possible. Response at sound-carrier frequency must be at least 30 db down. Response at vision-carrier frequency must be 6 db down ± 2 db. Output from sound channel may be negative.

* Remove 75-ohm termination when feeding into AE socket.

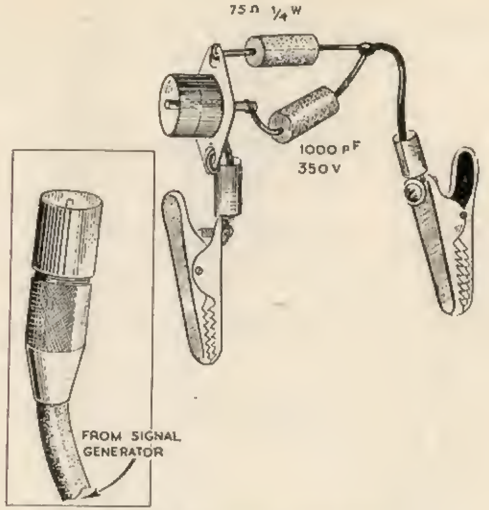


FIG. 9 (*a*).—TERMINATION DEVICE.

The signal-generator termination device shown above is intended for use with a signal generator having an output impedance of the order of 75 ohms, and should be connected in circuit when injecting a signal directly to the grids of the valves: it will not normally be required when injecting signals to the aerial-input socket of the receiver. The device shown below is for damping the primary winding of intermediate-frequency transformers whilst the secondary winding is being adjusted, and vice versa. It is important that the crocodile clips make good electrical connection with the receiver circuitry. For convenience, both units should be made up and kept available for use when required.

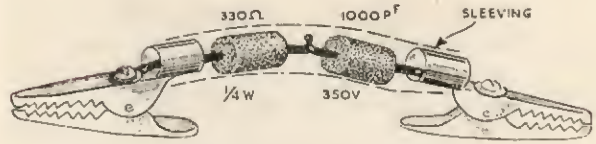


FIG. 9 (*b*).—DAMPING DEVICE.

TABLE 13.3.—ALIGNMENT OF BANDPASS-COUPLED I.F. AMPLIFIER

(Vision I.F. 16 Mc/s, Sound I.F 19·5 Mc/s.)

Step	*Connect Meter To:*	*Connect Signal-generator To:*	*Tune Circuit:*	*To:*	*At Mc/s*	*Remarks*
1	Vision det.	Grid V3	T3	Min.	19·5	High input level
2	,,	,,	L5	Max.	17·5	
3	,,	Grid V2	T2	Min.	19·5	
4	,,	,,	L4	Max.	17·5	Damper across L3
5	,,	,,	L3	Max.	17·5	Damper grid V3 to earth
6	,,	Grid mixer	T1	Min.	19·5	
7	,,	,,	L2	Max.	17·5	Damper across L1
8	,,	,,	L1	Max.	17·5	Damper grid V2 to earth
9	,,	,,	Check sensitivity and response curve by moving signal generator across band. Check input level at 19·5 Mc/s for same output reading to evaluate sound-rejection figure			
10	Sound det.	,,	L6 and sound circuits	Max.	19·5	

Other Remarks: If the final response curve slopes gradually up or down with frequency, L5 may be retuned slightly to achieve correction, otherwise re-check bandpass circuits. Response limits as given in Table 13.2. Output from sound detector may be negative.

In the case outlined in Table 13.3 the same remarks, concerning frequencies, apply, and it is generally very important to keep exactly to the manufacturers' chosen intermediate frequencies. The damping device used should not be too bulky, and should be efficiently earthed.

Signal Generator Alignment of Band I/III Receivers

The following procedure relates to the circuits shown in Fig. 5 (*a*).

The following equipment is required:

(1) An accurately calibrated signal generator giving C.W. and modulated output with an output impedance of 75 ohms, and having a range of 30–40 Mc/s for I.F. alignment, 40–70 Mc/s for Band I and 170–200 Mc/s for Band III R.F. alignment. The co-axial output lead should be terminated with an 82-ohm resistor (for I.F. alignment only) and the connection leads from the terminated co-axial lead *must* be kept as short as possible.

(2) A vision output meter. This may be a 20,000-ohms/volt meter switched to the 10 V D.C. range (meter resistance not less than 50,000 ohms), *e.g.*, an Avo Model 8 (not an Avo Model 7) in series with a 5·6k resistor on the hot side. Connect across R30. Alternatively, a 1,000-ohms/volt meter switched to the 1-mA D.C. range (meter resistance not more than 500 ohms), *e.g.*, Avo Model 7 (not Avo Model 8), may be used. Connect one lead to chassis, and the other in series with the earthy end of R30, by-passing the leads with a 1,000-pF condenser.

(3) For use as an I.F. transformer shunt, a ¼-watt, 1k resistor in series with a 1,000-pF miniature ceramic condenser, with short leads, are required.

(4) A sound-output meter. This may be a 3-ohm sound-output meter or an A.C. meter switched to the 1-volt or 50-volt A.C. range. A 3-ohm sound-output meter should be connected across the sound-output transformer secondary in place of the loudspeaker. If an A.C. meter is used switched to the 1-volt A.C. range, it should be connected across the sound-output transformer secondary: if the A.C. meter is switched to the 50-volt A.C. range, it should be connected across the sound-output transformer primary. In either case the loudspeaker should be left connected or a 3-ohm load connected in its place.

Procedure for I.F. Alignment

It is recommended that, whenever alignment of any stage is required, the whole alignment should be carried out.

The signal generator output should be connected to the tuner test point for all adjustments, and the tuner switched to a Band III channel for which coils are fitted (but not a channel which the set receives). Turn the contrast control to minimum and the volume control to maximum.

During vision I.F. alignment, adjust the input level of the

unmodulated I.F. input so as to maintain 2 volts D.C. across, or 400 μA through, R30.

For sound I.F. alignment, use a 30 per cent modulated signal, and adjust the input level to maintain an output of 50 mW or 0·5 V r.m.s. across the sound output transformer secondary, or 25 V r.m.s. across the sound-output transformer primary.

Carry out the adjustments in the order given in Table 13.4.

The correct tuning position for all cores except those specified in the following paragraph is the peak nearest the adjustment end.

The correct tuning position for the cores of IFT S1 (L22), IFT V2 (L12) and IFT V1 (L11) is the peak nearest the top (above chassis).

Note that L9 will not tune unless L10 has been correctly adjusted, and that the first operation must always be the sound rejector (L20).

The signal-generator frequency setting should not be disturbed when carrying out steps 1, 2, 3 and 4 in Table 13.4, and the shunt should always be connected between the nearest point on the chassis and the point specified in Table 13.4, using the shortest possible leads.

When the I.F. alignment procedure has been completed, the overall sound and vision response curves should be checked against those shown in Fig. 5 (*e*) and (*g*).

The procedure for aligning the circuits shown in Fig. 5 (*a*) with the use of a sweep generator is given later in this section.

TABLE 13.4.—I.F. ALIGNMENT OF BAND I/III RECEIVER

Step	*Inject, Mc/s*	*MOD/ C.W.*	*Shunt*	*Adjust*	*Response*	*Remarks*
1	38·15	C.W.	—	L20	Min. vis.	Sound Rejection
2	38·15	Mod.	—	L24 (Top)	Max. sound	
3	38·15	Mod.	—	L23 (Bot.)	Max. sound	
4	38·15	Mod.	—	L22	Max. sound	Top peak
5	Unscrew L10 core flush with base of former.					
6	Set L9 core down $\frac{9}{16}$ in. from top of former (this is approx. working position).					
7	35·75	C.W.	V4 pin 7 (Anode)	L14 (Bot.)	Max. vision	
8	35·75	C.W.	V5A pin 7 (Anode)	L13 (Top)	Max. vision	
9	36·75	C.W.	V3 pin 7 (Anode)	L12	Max. vision	Top peak
10	36·75	C.W.	V4 pin 2 (Grid)	L11	Max. vision	
11	Repeat operations No. 7, 8, 9, 10.					
12	35	C.W.	—	L10 (Bot.)	Max. vision	
13	36·75	C.W.	V3 pin 2 (Grid)	L7	Max. vision	Top of Tuner
14	33·15	C.W.	—	L9 (Top)	Min. vision	

Sweep Generator (Wobbulator) Alignment, Band I Models

Additional test gear requirements to those in the previous section are given in Table 13.5.

TABLE 13.5

Item	*Remarks*
Sweep generator . . .	Sweep width 10 Mc/s. Other points as for signal generator.
Oscilloscope . . .	Required if no display in sweep generator. Should have bright trace of good linearity. Time-base must be locked to or driven from generator. Amplifier with low hum level essential—giving at least 1 in. deflection for 1 V input.
Connectors . . .	As for signal-generator procedure.

Procedure

Although the procedure is essentially the same as in the signal-generator case, the use of a sweep generator is very desirable in that the full effect of any adjustment is clearly discernible. There are, of course, disadvantages, but the clear view of the response of a part or complete amplifier is a great time saver and assists in producing more accurate results.

It is necessary to have some source of frequency reference, and for this purpose the signal generator is lightly coupled to the

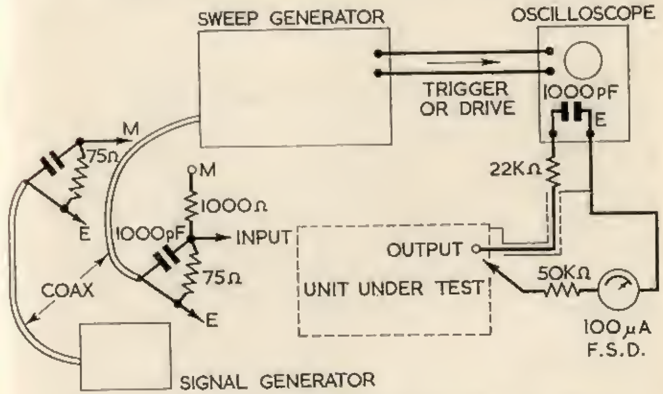


FIG. 10.—ARRANGEMENT OF TEST EQUIPMENT FOR SWEEP GENERATOR ALIGNMENT.

TABLE 13.6.—ALIGNMENT OF STAGGER-TUNED T.R.F. RECEIVER BY SWEEP GENERATOR METHOD

Step	Connect:	To:	Connect:	To:	Tune Circuit:	To:	At/For Curve:	Remarks
1	Meter	Vision det.	Signal generator	Grid V1	T1, 2, 3	Min.	41·5 Mc/s	2 V ouput approx.
2	Scope	”	Sweep generator	Grid V3	L4 and L5	Symmetry	See Fig. 11 *a*	Marker at 43·25 Mc/s
3	”	”	”	Grid V1	L2 and L3	”	See Fig. 11 *b*	Marker at 42·25 and 44·25 Mc/s
4	”	”	”	AE socket *	L1	”	See Fig. 11 *c*	Marker at 43·25 Mc/s
5	”	”	”	”	Check with marker pip:	Carrier position (6 db down—50%) 42·0 Mc/s point (approx. 6 db down)		
6	”	Sound det.	”	”	L6 and sound circuits	Max. and symmetry	See Fig. 11 *d*	Marker at 41·0 Mc/s

Other Remarks: If the display (oscilloscope) amplifier is linear, the following hold

1 db down = approx. 90% 6 db down = approx. 50%
3 db down = approx. 70% 20 db down = approx. 10%

The percentages apply to curve height. In general, it is very unsafe to rely upon measurements of greater than 6 db by inspection of the trace. Measurement of sound rejection must be made as in Tables 13.2 and 13.3 using signal generator.

* Remove 75-ohm termination when feeding into AE socket.

TABLE 13.7.—ALIGNMENT OF BANDPASS COUPLED I.F. AMPLIFIER BY SWEEP GENERATOR METHOD
(Vision I.F. 16·0 Mc/s, Sound I.F. 19·5 Mc/s.)

Step	Connect:	To:	Connect:	To:	Tune Circuit:	To:	At/For Curve:	Remarks
1	Meter	Vision det.	Signal generator	Grid V1	T1, 2, 3	Min.	19·5 Mc/s	
2	Scope	”	Sweep generator	Grid V2	L3, 4, 5	Symmetry	See Fig. 11 *e*	Marker at 17·5 Mc/s
3	”	”	”	Grid V1	L1 and L2	”	See Fig. 11 *f*	Marker at 17·5 Mc/s
4	”	”	”	”	Check with marker pip:	16·0 Mc/s—carrier position (6 db down) 19·0 Mc/s point (approx. 6 db down)		
5	”	Sound det.	”	”	L6 and sound circuits	Max. and symmetry	See Fig. 11 *d*	Marker at 19·5 Mc/s

Other Remarks: The means of measuring sound rejection must be the same as in Tables 13.2 and 13.3, *i.e.*, using signal generator and meter.

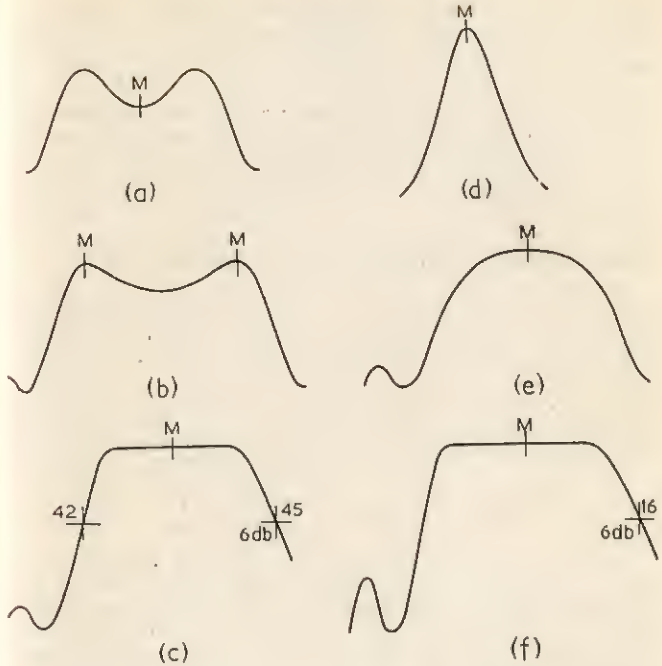


FIG. 11.—RESPONSE CURVES SEE TABLES 13.6 AND 13.7.

Curves (*e*) and (*f*) are shown with the lower frequencies on the left, higher on the right, for comparison with the T.R.F. stagger-tuned circuits. When, however, viewed on an oscilloscope set up in the normal fashion, they would appear reversed.

sweep input as shown in Fig. 10 (unless the wobbulator contains its own markers). The presence of the carrier at a frequency within the passband causes a beat pattern to form at the time when the sweep-generator output passes this point. The pattern appears on the trace as a small blip, and can be made clear by restricting the oscilloscope band-width to the minimum required for proper reproduction of the waveform. The resistor and condenser across the oscilloscope terminals in Fig. 10 are for this purpose.

Note that the sweep generator is not really suitable for the alignment of the trap circuits. In Tables 13.6 and 13.7 the traps are aligned initially with the signal generator connected to the input of the amplifier in question. The visual representation of the

response curve makes it possible to accomplish the alignment in rather fewer steps than previously and permits a "halfway check" to be made, whereupon it should be fairly obvious whether the adjustment of the remaining circuits will produce the required curve.

The sweep-generator input level is an important consideration, and should not be increased to a point where overloading sets in (this may give curves with ideally flat tops). The gain of the oscilloscope amplifier should be set so that a 2-V input is always used. Furthermore, the marker input should be as small as possible.

Sweep Generator I.F. Alignment of Band I/III Receivers

The following sweep-generator alignment procedure is for the circuits shown in Fig. 5 (*a*). The tuner should be switched to an unused Band III channel for which coils are fitted, and the contrast and volume controls turned to minimum. Connect a 1·5-V bias battery (negative lead) to the A.G.C. line at C27. The co-axial output lead from the sweep generator should be terminated with an 82-ohm resistor (for I.F. alignment only) and the connection leads from the terminated co-axial lead must be kept as short as possible. For vision alignment, connect the sweep generator "Y input" to the junction of L15/L16. For sound alignment, connect the sweep generator "Y input" to the junction of R85, R83 and C70. No I.F. transformer shunts are used.

The stages should be aligned in the following order: IFT S1 and S2 (to response curve shown in Fig. 5 (*d*)); IFT V3 (to response curve shown in Fig. 5 (*b*)); IFT V1, V2 and sound rejector (to response curve shown in Fig. 5 (*c*)). Then check that the overall vision and sound I.F. response curves are as shown in Figs. 5 (*e*) and 5 (*g*) respectively. Connect the wobbulator as indicated in the figures, adjusting its output to maintain the cathode-ray tube trace amplitude quoted on each curve.

Alignment of Band I Receiver R.F. Circuits

There is, perhaps, more deviation between manufacturers in the question of the pre-mixer or R.F. circuits than there is in general I.F. amplifier technique. Nevertheless, there are one or two basic points which must be realised. The oscillator must be tuned to the right frequency, and the R.F. circuits must be aligned for maximum gain, having a band-width sufficient to cover both vision and sound channels without disturbing the I.F. response already obtained.

The best way of adjusting the oscillator frequency is to set the signal generator to the desired sound-channel frequency, and, feeding the output into the aerial socket, to set the oscillator trimmer for maximum sound output. Care should be taken to use a small signal, or the sound A.G.C. circuits (if any) will make the adjustment flat.

With only a signal generator available the R.F. circuits can be aligned by connecting the generator to the aerial socket and the meter to the vision detector as before. The aerial circuit will, in all probability, be tuned to the centre of the desired band, and can be trimmed for maximum output. If followed by a bandpass filter the damping clip used for I.F. alignment will serve again. The overall curve can then be inspected. Note that an oscillator frequency higher than the signal frequency reverses the relationship between vision and sound carriers in the I.F. channel.

Should there be only two pre-mixer circuits, they will be staggered, and it is probable that the resonant frequency of one will be near to the vision carrier and the other to the sound carrier. The maker's instructions in this respect must be closely followed, or some deterioration in performance under weak signal conditions must be expected.

Using a sweep generator (once the oscillator has been trimmed), it is possible to form an immediate idea of the effect of the R.F. circuits. Due to the fairly wide band-width of any pre-mixer bandpass circuit, it is as well to use the damping clip as with the signal-generator method. The marker can be set at the mid-band frequency and each circuit adjusted for peak response. The input circuit may be off trimmed within reasonable limits to balance the curve shape.

ALIGNMENT OF TUNERS

Turret Tuners

As has been indicated, it is possible to carry out a number of adjustments on tuners, and the equipment needed is as indicated in Table 13.5.

Most tuners have a test point—shown at "T.P." in Fig. 5 (*a*). The tuner must be powered exactly as in the receiver and the oscilloscope connected to the test point with the Y gain set according to the tuner manufacturer's instructions, otherwise for a sensitivity of about 1 V for full deflection.

The operation best carried out first is to set up all the oscillator frequencies. To do this it is either necessary to use a highly accurate wavemeter or to feed the signal generator into the aerial terminal set near to the right frequency and search about for a beat pattern on the oscilloscope trace. When this is found, the signal-generator output should be reduced to the minimum level before final adjustments to avoid "pulling". The oscillator frequencies for channels 1–13 for the standard I.F. (34·65 Mc/s) are given below. For other I.F.s add the vision-carrier frequency to the vision I.F.

Channels	1	2	3	4	5	6	7
Frequency (Mc/s)	79·65	86·4	91·4	96·4	101·4	214·4	219·4

Channels	8	9	10	11	12	13
Frequency (Mc/s)	224·4	229·4	234·4	239·4	244·4	249·4

Commence with channel 13 and work down, making *sure* that the fine tuning control is set at exactly half rotation. Do not adjust C16 (Fig. 5) unless one channel will not centre with the screw core in its oscillator coil. When C16 has been moved, all oscillator coils will have to be readjusted. When the R.F. circuits are to be adjusted, connect the oscilloscope to the test point as before and the wobbulator to the aerial socket. Make sure that the wobbulator output exactly matches the tuner input. If in doubt fit a 6- or 12-db attenuator.

The signal generator may be used as a marker as shown in Fig. 10, and in each case tune the generator to the frequency midway between vision and sound. The vision, sound and mid frequencies are given below:

Channel.	1	2	3	4	5	6	7
Vision freq. (Mc/s)	45	51·75	56·75	61·75	66·75	179·75	184·75
Mid freq. (Mc/s)	43·25	50	55	60	65	178	183
Sound freq. (Mc/s)	41·5	48·25	53·25	58·25	63·25	176·25	181·25

Channel.	8	9	10	11	12	13
Vision freq. (Mc/s.)	189·75	194·75	199·75	204·75	209·75	214·75
Mid freq. (Mc/s)	188	193	198	203	208	213
Sound freq. (Mc/s)	186·25	191·25	196·25	201·25	206·25	211·25

With a turret tuner start at the highest channel and work down. Set up the equipment to produce a curve and tune the aerial coil to produce maximum curve height at the mid frequency. If, after several channels have been so adjusted, there is a severe tilt to the curve on *all*, C8 or C11 (Fig. 5) should be adjusted for a level curve. Then recheck all channels. If there is a trimmer condenser in the aerial circuit, it should not be moved unless the aerial slugs cannot be moved to reach the desired tuning point. After such an adjustment, retune each aerial coil. Tuner curves should fall within the limits shown in Fig. 5 (*f*). Do not try to reset the R.F. anode and mixer grid coils: it is best to obtain replacement biscuits.

(*Continued on page 217*)

TABLE 13.7.—TELEVISION RECEIVER I.F.S

Models marked ● are aligned to upper sideband

Model	*Vision I.F. (Mc/s)*	*Sound I.F. (Mc/s)*
ACE		
Astra	13·3	9·8
Capella	13·3	9·8
Jupiter	13·3	9·8
Orion	13·3	9·8
V554F	13·3	9·8
V554S	13·3	9·8
553	13·3	9·8
ALBA		
MT341	14·0	10·5
MT362	14·0	10·5
MT441	14·0	10·5
MT442	14·0	10·5
T301	16·0	19·5
T304	16·0	19·5
T312	16·0	19·5
T321	34·65	38·15
T324	34·65	38·15
T331 ●	T.R.F.	T.R.F.
T336	34·5	38·0
T336B	34·5	38·0
T336FM	34·5	38·0
T352	14·0	10·5
T372	16·0	19·5
T372/B	16·0	19·5
T392	16·0	19·5
T394	16·0	19·5
T411	T.R.F.	T.R.F.
T421	T.R.F.	T.R.F.
T424	34·65	38·15
T431 ●	T.R.F.	T.R.F.
T432 ●	T.R.F.	T.R.F.
T436	34·65	38·15
T472	16·0	19·5
T483	16·0	19·5
T483/B	16·0	19·5
T484	16·0	19·5
T492	16·0	19·5
T493	16·0	19·5
T494	16·0	19·5
T504	16·0	19·5
T524	34·65	38·15
T524FM	34·5	38·0
T536	34·65	38·15
T641	34·5	38·0
T644	34·5	38·0
T655	34·5	38·0
T656	34·5	38·0
T717	34·5	38·0
T721	34·5	38·0
T724FM	34·5	38·0
T741FM	34·5	38·0
ALBA (*contd.*)		
T744FM	34·5	38·0
T909	34·5	38·0
TRG9872	16·0	19·5
TR9872/B	16·0	19·5
TR9874	16·0	19·5
TRG0971	16·0	19·5
TRG0971B	16·0	19·5
TRG0972	16·0	19·5
TRG1974	16·0	19·5
AMBASSADOR		
TV1	15·75	19·25
TV2	15·75	19·25
TV4	15·75	19·25
TV5	15·75	19·25
TV7	15·75	19·25
TV7R	15·75	19·25
TV9	15·75	19·25
TV9F	15·75	19·25
TV10	15·75	19·25
TV10C	15·75	19·25
TV10CC	15·75	19·25
TV10CR	15·75	19·25
TV11	15·75	19·25
TV11CC	15·75	19·25
TV14CC	34·25	37·75
TV14TM	34·25	37·75
TV15C	34·25	37·75
TV15CC	34·25	37·75
TV15CR	34·25	37·75
TV17C	34·25	37·75
TV17CC	34·25	37·75
TV17CR	34·25	37·75
TV17TM	34·25	37·75
TV19CC	34·25	37·75
TV19CD	34·25	37·75
TV19CT	34·25	37·75
TV19TM	34·25	37·75
TV20CC	34·25	37·75
TV20CD	34·25	37·75
TV20CT	34·25	37·75
TV21C	34·25	37·75
TV192TM	34·25	37·75
21CC	34·25	37·75
ARGOSY		
C4 *	14·0	10·5
CTV/5	14·0	10·5
CTV/517	14·0	10·5
T2	14·0	10·5
T3	14·0	10·5
TT5/5	14·0	10·5
TV1412L	14·0	10·5
TV1412B	14·0	10·5

* 33·5 Mc/s sound and 37 Mc/s vision in Band I/III versions.

Model	*Vision I.F. (Mc/s)*	*Sound I.F. (Mc/s)*
ARGOSY (*contd.*)		
14K41	34·65	38·15
17C41	34·65	38·15
17F41	34·65	38·15
17K40	34·65	38·15
17K41	34·65	38·15
17K43	34·65	38·15
21K40	34·65	38·15
21L40	34·65	38·15
BAIRD		
Countryman *	12·6	9·1
Elizabethan 17	13·0	9·5
Everyman: T29A	T.R.F.	T.R.F.
T29C	T.R.F.	T.R.F.
Frobisher 14	13·0	9·5
Shakespeare 17	13·0	9·5
Townsman *	12·6	9·1
B155	T.R.F.	T.R.F.
B175	T.R.F.	T.R.F.
C1815	13·0	9·5
C200: Ch. 1, 2, 4	14·0	10·5
Ch. 3, 5	15·25	11·75
C2017	13·0	9·5
C2117	34·5	38·0
C5614	34·25	37·75
C5617	34·25	37·75
C5621	34·25	37·75
C5717	34·25	37·75
C5720	34·25	37·75
CD5617	34·25	37·75
D2117	34·5	38·0
P165 *	12·6	9·1
P167	13·0	9·5
P1712	13·0	9·5
P1812	13·0	9·5
P1814	13·0	9·5
P1815	13·0	9·5
P2014	13·0	9·5
P2017	13·0	9·5
P2114	34·5	38·0
P2117	34·5	38·0
T11 ●	T.R.F.	T.R.F.
T18	T.R.F.	T.R.F.
T20	T.R.F.	2·5
T21	T.R.F.	T.R.F.
T25	T.R.F.	T.R.F.
T26	T.R.F.	T.R.F.
T29	T.R.F.	T.R.F.
T163	12·6	9·1
T164 *	12·6	9·1
T165 *	12·6	9·1
T167	13·0	9·5
T172	13·0	9·5
T172S	13·0	9·5
BAIRD (*contd.*)		
T5614	34·25	37·75
T5617	34·25	37·75
T5719	34·25	37·75
167S	13·0	9·5
172S	13·0	9·5
BANNER		
B112	16·0	19·5
B114	34·5	38·0
B117	34·5	38·0
B117C	34·5	38·0
B124	16·0	19·5
B412	16·0	19·5
B414	16·0	19·5
B416	16·0	19·5
B436	16·0	19·5
BT112	16·0	19·5
BT114	16·0	19·5
BT117	34·5	38·0
BT117C	34·5	38·0
BEAUMONT		
S17/FM	34·65	38·15
T	34·65	38·15
BEETHOVEN		
B77	34·75	38·25
B77C	34·75	38·25
B80	34·75	38·25
B94	34·75	38·25
B94C	34·75	38·25
B95	34·75	38·25
B98	34·75	38·25
B99	34·75	38·25
B106/1	34·75	38·25
B208	34·75	38·25
TV50	T.R.F.	T.R.F.
TV50M	T.R.F.	T.R.F.
BOWJECTION		
Clubman	15·0	11·5
Mk. 1	16·0	19·5
Mk. 2	16·0	19·5
BUSH		
M59	34·65	38·15
M69	34·65	38·15
T36 †	34·65	38·15
T57	34·65	38·15
T67	34·65	38·15
T75C	34·65	38·15
T76C	34·65	38·15
T85C	34·65	38·15

* 13·0, 9·5 or 13·25, 9·75 (Birmingham).
† Earlier models have 34·5 Mc/s vision and 38·0 Mc/s sound

Model	*Vision I.F. (Mc/s)*	*Sound I.F. (Mc/s)*
BUSH (*contd.*)		
T91	T.R.F.	0·725
TRG12A	T.R.F.	T.R.F.
TRG12B	T.R.F.	T.R.F.
TRG24	16·0	19·5
TUG12	T.R.F.	T.R.F.
TUG24	16·0	19·5
TUG26	16·0	19·5
TUG34	16·0	19·5
TUG34A	16·0	19·5
TUG36	16·0	19·5
TUG36C *	34·65	38·15
TUG58	34·65	38·15
TUG59	34·65	38·15
TUG68	34·65	38·15
TUG69	34·65	38·15
TV1	T.R.F.	0·725
TV2	T.R.F.	0·725
TV11	T.R.F.	T.R.F.
TV12	T.R.F.	T.R.F.
TV22	16·0	19·5
TV24	16·0	19·5
TV24C *	34·65	38·15
TV32	16·0	19·5
TV33 *	34·65	38·15
TV36	16·0	19·5
TV36C *	34·65	38·15
TV43 *	34·65	38·15
TV53	34·65	38·15
TV56	34·65	38·15
TV62	34·65	38·15
TV63	34·65	38·15
TV66	34·65	38·15
TV75	34·65	38·15
TV76	34·65	38·15
TV77	34·65	38·15 †
TV79	34·65	35·15
TV80	34·65	38·15
TV83	34·65	38·15
TV84	34·65	38·15
TV85	34·65	38·15
TV85C	34·65	38·15
TV86	34·65	38·15
TV86C	34·65	38·15
TV94, 5, 6, 9	34·65	38·15
Type 63 Receiver	34·65	38·15
CHAMPION		
TV12T	16·0	19·5
TV17	16·0	19·5
COLUMBIA		
C501	14·0	10·5
C502	14·0	10·5
COLUMBIA (*contd.*)		
C503	13·0	9·5
C505	16·0	19·5
COSSOR		
54	6·0	—
65	6·0	—
137	5·3	—
237	5·3	—
437	5·3	—
900 ●	6·0	465 kc/s
901 ●	T.R.F.	2·2
902 ●	T.R.F.	2·2
912 ●	T.R.F.	2·2
914 ●	T.R.F.	2.2
916 ‡	13·0	9·5
917 ‡	13·0	9·5
918	13·0	9·5
919	16·0	19·5
920	16·0	19·5
921	16·0	19·5
923	13·0	9·5
924	16·0	19·5
925	16·0	19·5
926	16·0	19·5
927	13·6	10·1
928	16·0	19·5
928F	13·6	10·1
929	13·6	10·1
929F	13·6	10·1
930	13·6	10·1
930F	13·6	10·1
930N	13·6	10·1
930T	13·6	10·1
930TF	13·6	10·1
930TN	13·6	10·1
931	13·6	10·1
931F	13·6	10·1
932	13·6	10·1
933	13·6	10·1
933F	13·6	10·1
933N	13·6	10·1
934	13·6	10·1
934F	13·6	10·1
934N	13·6	10·1
935	34·5	38·0
937	34·5	38·0
937A	34·65	38·15
938	34·5	38·0
938A	34·65	38·15
938F	34·5	38·0
939	34·5	38·0
939A	34·5	38·0
939F	34·5	38·0
942	34·5	38·0

* Earlier models have 34·5 Mc/s vision and 38·0 Mc/s sound.
† Dual channel I.F. strip. (10·7 Mc/s for radio.)
‡ Some models, 19·5 Mc/s, 16 Mc/s.

Model	Vision I.F. (Mc/s)	Sound I.F. (Mc/s)
COSSOR (*contd.*)		
943	34·65	38·15
944	34·65	38·15
945	34·65	38·15
945A	34·65	38·15
945B	34·65	38·15
945F	34·65	38·15
946	34·65	38·15
947	34·65	38·15
947A	34·65	38·15
947F	34·65	38·15
948	34·65	38·15
948F	34·65	38·15
949	34·65	38·15
1210	6·0	465 kc/s
DECCA		
Beaudecca: Ch. 1	13·0	9·5
Decola: Ch. 1	13·0	9·5
Ch. 4	14·0	10·5
Dual Unit:		
Ch. 1ss, 3, 4, 5	14·0	10·5
Ch. 1ds	13·0	9·5
Ch. 2	15·0	11·5
Knightsbridge:		
Ch. 1	13·0	9·5
Ch. 4	14·0	10·5
D14	14·0	10·5
D17	14·0	10·5
D17C	14·0	10·5
DM1	34·65	38·15
DM2/C	34·65	38·15
DM3	34·65	38·15
DM3/C	34·65	38·15
DM4	34·65	38·15
DM4/C	34·65	38·15
DM4/LRC	34·65	38·15
DM5	34·65	38·15
DM14	34·65	38·15
DM17	34·65	38·15
DMC17	34·65	38·15
DMCD17	34·65	38·15
DMC/D18	34·65	38·15
DMC/D21	34·65	38·15
DM21/C	34·65	38·15
DM35/C	34·65	38·15
DM45	34·65	38·15 *
101 Mk. 1: Ch. 1	13·5	10·0
Ch. 4	14·0	10·5
101 Mk. 2: Ch. 1, 4	14·0	10·5
111: Ch. 1, 4, 5	14·0	10·5
Ch. 2, 3	15·0	11·5
121: Ch. 1ss, 5	13·5	10·0
Ch. 1ds	13·0	9·5
Ch. 2	15·0	11·5
Ch. 3, 4	14·0	10·5

Model	Vision I.F. (Mc/s)	Sound I.F. (Mc/s)
DECCA (*contd.*)		
131: Ch. 1	13·0	9·5
Ch. 4	14·0	10·5
141: Ch. 1ss, 5	13·5	10·0
Ch. 1ds	13·0	9·5
Ch. 2	15·0	11·5
Ch. 3, 4	14·0	10·5
222	14·0	10·5
300	14·0	10·5
333	14·0	10·5
444	34·65	38·15
1000: Ch. 1ss, 3, 4, 5	14·0	10·5
Ch. 1ds	13·0	9·5
Ch. 2	15·0	11·5
DEFIANT		
P50	34·65	38·15
T141	34·65	38·15
T171	34·65	38·15
T172	34·65	8·15
T176	34·65	38·15
T1410	34·65	38·15
T1710	34·65	38·15
T1720	34·65	38·15
T1760	34·65	38·15
TA91	34·65	38·15
TR947C	13·0	39·5
TR947CM	14·0	10·5
TR947T	13·0	9·5
TR947TM	14·0	10·5
TR1247	13·0	9·5
TR1247M	14·0	10·5
TR1248R	13·0	9·5
TR1250CL	14·0	10·5
TR1250CM	14·0	10·5
TR1250TL	14·0	10·5
TR1250TM	14·0	10·5
TR1252C	14·0	10·5
TR1252T	14·0	10·5
TR1453T	14·0	10·5 †
TR1454/CB3	34·0	37·5
TR1454/TB3	34·0	37·5
TR1455/B3	34·0	37·5
TR1456C	34·0	37·5
TR1456/CT	34·0	37·5
TR1456T	34·0	37·5
TR1456TL	34·0	37·5
TR1753C	14·0	10·5
TR1753T	14·0	10·5
TR1754/CB3	34·0	37·5
TR1754/TB3	34·0	37·5
TR1755/B3	34·0	37·5
TR1756C	34·0	37·5
TR1756T	34·0	37·5
TR1756TD	34·0	37·5
41	34·65	38·15

* Dual channel I.F. strip. (10·7 Mc/s for radio.)
† 15 Mc/s vision and 11·5 Mc/s sound for North and Scottish sets.

Model	Vision I.F. (Mc/s)	Sound I.F. (Mc/s)
DEFIANT (*contd.*)		
71	34·65	38·15
72	34·65	38·15
76	34·65	38·15
410	34·65	38·15
710	34·65	38·15
717	34·65	381·5
720	34·65	38·15
760	34·65	38·15
1403	34·65	38·15
2109	34·65	38·15
4109	34·65	38·15
7101	34·65	38·15
7109	34·65	38·15
7109FM	34·65	38·15
7209	34·65	38·15
7609	34·65	38·15
7609FM	34·65	38·15
DYNATRON		
B314/1	20 *	23·5 *
K349	20 *	23·5 *
P314/2	20 *	23·5 *
TV24	20 *	23·5 *
TV24A	20 *	23·5 *
TV26	19·5	23·0
TV27	19·5	23·0
TV27A, B, C	19·5	23·0
TV28	35·0	38·5
TV29	34·5	38·0
TV29M	34·5	38·0
TV30	34·65	38·15
TV32	34·5	38·0
TV33	34·65	38·15
TV34	34·65	38·15
TV36	34·65	38·15
TV36F	34·65	38·15
TV37F	34·65	38·15
TV38	34·65	38·15 †
TV39/F	34·65	38·15
TV40	34·65	38·15 †
TVC40	34·65	38·15
EKCO		
T141	16·2	19·7
T161	16·2	19·7
T162	16·2	19·7
T164	16·2	19·7
T165	16·2	19·7
T205 (early)	16·2	19·7
T205 (later)	16·0	19·5
T207	16·0	19·5
T216	16·0	19·5
T217	16·0	19·5
T221	16·0	19·5
T231	16·0	19·5

Model	Vision I.F. (Mc/s)	Sound I.F. (Mc/s)
EKCO (*contd.*)		
T231F	16·0	19·5
T283	34·65	38·15
T284	34·65	38·15
T293	34·65	38·15
T310	34·65	38·15
T311	34·65	38·15
T312	34·65	38·15
T326	34·65	38·15
T327	34·65	38·15
T330	34·65	38·15
T330F	34·65	38·15
T331	34·65	38·15
T342	34·65	38·15
T344	34·65	38·15
T345	34·65	38·15 †
T356	34·65	38·15 †
TC138	16·2	19·7
TC140	16·2	19·7
TC155	16·2	19·7
TC162	16·2	19·7
TC165	16·2	19·7
TC166	16·2	19·7
TC174	16·2	19·7
TC178 (early)	16·2	19·7
TC178 (later)	16·0	19·5
TC185	16·2	19·7
TC196 (early)	16·2	19·7
TC196 (later)	16·0	19·5
TC206 (early)	16·2	19·7
TC206 (later)	16·0	19·5
TC208	16·0	19·5
TC209	16·0	19·5
TC209/1	34·65	38·15
TC220	16·0	19·5
TC220/1	34·65	38·15
TC248	16·0	19·5
TC267	16·0	19·5
TC267/1	34·65	38·15
TC268	16·0	19·5
TC268/1	34·65	38·15
TC313	34·65	38·15
TC313F	34·65	38·15
TC346	34·65	38·15 †
TGC316	34·65	38·15
TCG337	34·65	38·15
TMB272	16·0	19·5
TP308	34·65	38·15
TRC124	T.R.F.	T.R.F.
TRC139	16·2	19·7
TRC1124	T.R.F.	T.R.F.
TS16	T.R.F.	T.R.F.
TS46/1	T.R.F.	T.R.F.
TS88	T.R.F.	T.R.F.
TS93	T.R.F.	T.R.F.
TS105	T.R.F.	T.R.F.

* London models. Birmingham models are 24·5 Mc/s vision, 21 Mc/s sound.
† Dual channel I.F. strip. (10·7 Mc/s for radio.)

Model	Vision I.F. (Mc/s)	Sound I.F. (Mc/s)
EKCO (*contd.*)		
TS114	T.R.F.	T.R.F.
TS188	T.R.F.	T.R.F.
TS193	T.R.F.	T.R.F.
TS1105	T.R.F.	T.R.F.
TS1114	T.R.F.	T.R.F.
TSC30	T.R.F.	T.R.F.
TSC48	T.R.F.	T.R.F.
TSC48/1	T.R.F.	T.R.F.
TSC91	T.R.F.	T.R.F.
TSC91/1	T.R.F.	T.R.F.
TSC93	T.R.F.	T.R.F.
TSC102	T.R.F.	T.R.F.
TSC113	T.R.F.	T.R.F.
TSC148	T.R.F.	T.R.F.
TSC193	T.R.F.	T.R.F.
TSC1102	T.R.F.	T.R.F.
TSC1113	T.R.F.	T.R.F.
TSC1124	T.R.F.	T.R.F.
TU142	16·2	19·7
TU169	16·2	19·7
TU211	16·2	19·7
EMERSON		
E700	34·75	38·25
E701	34·75	38·25
ENGLISH ELECTRIC		
C42 *	35·5	39·0
C42A	34·65	38·15
C42A.F.M.	34·65	38·15
C42F.M.	34·65	38·15
C45	34·65	38·15
C45A	34·65	38·15
C45A.F.M.	34·65	38·15
C45F.M.	34·65	38·15
C46	34·65	38·15
C46A	34·65	38·15
C46A.F.M.	34·65	38·15
C46F.M.	34·65	38·15
T40 *	35·5	39·0
T40A	34·65	38·15
T40A.F.M.	34·65	38·15
T40F.M.	34·65	38·15
T41 *	35·5	39·0
T41A	34·65	38·15
T41A.F.M.	34·65	38·15
T41F.M.	34·65	38·15
16C14: Ch. 1, 4, 5	23·5	27·0
Ch. 2, 3	20·0	23·5
16C19	35·5	39·0
16C19D	35·5	39·0
16C19F	35·5	39·0
16T11D	35·5	39·0

Model	Vision I.F. (Mc/s)	Sound I.F. (Mc/s
ENGLISH ELECTRIC (*contd.*)		
16T11F	35·5	39·0
16T18	35·5	39·0
16T18F	35·5	39·0
1550: Ch. 1	16·5	20·0
Ch. 2, 4	18·0	21·5
1550M: Ch. 1	16·5	20·0
Ch. 2, 4	18·0	21·5
1650: Ch. 1, 4, 5	23·5	27·0
Ch. 2, 3	20·0	23·5
1651: Ch. 1, 4, 5	23·5	27·0
Ch. 2, 3	20·0	23·5
ETRONIC		
CV1050 †	T.R.F.	T.R.F.
CV1250 †	T.R.F.	T.R.F.
ECS2231	14·0	10·5
ESC2231/B	14·0	10·5
ECS2231/B/HM	14·0	10·5
ECS2231/HM	14·0	10·5
ECV1523	14·0	10·5
ECV1524	14·0	10·5
ECV1527	14·0	10·5
ETV1527	14·0	10·5
ETV1536	16·0	19·5
ETV1637	16·0	19·5
HV203/A ●	T.R.F.	T.R.F.
HV203/B	T.R.F.	T.R.F.
HV204/A ●	T.R.F.	T.R.F.
HV204/B	T.R.F.	T.R.F.
FERGUSON		
45	34·65	38·15
103T	16·0	19·5
105T	16·0	19·5
113T	16·0	19·5
135T	16·0	19·5
143T	16·0	19·5
145T	16·0	19·5
203T	34·65	38·15
204T	34·65	38·15
205T	34·65	38·15
206T	34·65	38·15
213T	34·65	38·15
214T	34·65	38·15
217T	34·65	38·15
235T	34·65	38·15
236T	34·65	38·15
244T	34·65	38·15
245T	34·65	38·15
246T	34·65	38·15
247T	34·65	38·15
305T	34·65	38·15
306T	34·65	38·15
307T	34·65	38·15

* 34·65 Mc/s vision and 38·15 Mc/s sound on later versions of these models (after Serial No. 15001).

† London models aligned to upper sideband.

Model	Vision I.F. (Mc/s.)	Sound I.F. (Mc/s)
FERGUSON (*contd.*)		
308T	34·65	38·15
315T	34·65	38·15
317T	34·65	38·15
405T	34·65	38·15
406T	34·65	38·15
407T	34·65	38·15
408T	34·65	38·15
416T	34·65	38·15 *
436T	34·65	38·15 *
438T	34·65	38·15 *
454T	34·65	38·15
506T	34·65	38·15
508T	34·65	38·15
546T	34·65	38·15
841T	T.R.F.	T.R.F.
841T/12	T.R.F.	T.R.F.
842T	T.R.F.	T.R.F.
843T	T.R.F.	T.R.F.
941T	T.R.F.	T.R.F.
941TS	T.R.F.	T.R.F.
943T	T.R.F.	T.R.F.
945TRG	T.R.F.	T.R.F.
951T	T.R.F.	T.R.F.
953T	T.R.F.	T.R.F.
955TRG	T.R.F.	T.R.F.
957T	T.R.F.	T.R.F.
968T	T.R.F.	T.R.F.
968TS	T.R.F.	T.R.F.
978T	T.R.F.	T.R.F.
983T	16·0	19·5
984T	16·0	19·5
988T	16·0	19·5
989T	16·0	19·5
990T	16·0	19·5
990T(N)	16·0	19·5
991T	16·0	19·5
991T(N)	16·0	19·5
992T	16·0	19·5
992T(N)	16·0	19·5
993T	16·0	19·5
993T(N)	16·0	19·5
994T	16·0	19·5
994T(N)	16·0	19·5
995T	16·0	19·5
995T(N)	16·0	19·5
996T	16·0	19·5
996T(N)	16·0	19·5
997T	16·0	19·5
997T(N)	16·0	19·5
998T	16·0	19·5
998T(N)	16·0	19·5
FERRANTI		
T129	T.R.F.	T.R.F.
T129M	T.R.F.	T.R.F.

Model	Vision I.F. (Mc/s)	Sound I.F. (Mc/s)
FERRANTI (*contd.*)		
T136	T.R.F.	10·0
T138	T.R.F	T.R.F.
T138M	T.R.F.	T.R.F.
T1001	34·65	38·15
T1002	34·65	38·15
T1002/1	34·65	38·15
T1006	34·65	38·15
T1011	34·65	38·15
T1021	34·65	38·15
T1023	34·65	38·15
T1023F	34·65	38·15
T1024	34·65	38·15 †
T1125	16·0	19·5
T1146	T.R.F.	10·0
T1205	T.R.F.	T.R.F.
T1205(M)	T.R.F.	T.R.F
T12055	16·0	19·5
T1215	16·0	19·5
T1225	16·0	19·5
T1246	T.R.F.	10·0
T1325	16·0	19·5
T1405	T.R.F.	T.R.F.
T1405(M)	T.R.F.	T.R.F.
T1405S	16·0	19·5
T1415	16·0	19·5
T1425	16·0	19·5
T1505	T.R.F.	T.R.F.
T1505(M)	T.R.F.	T.R.F.
T1505S	16·0	19·5
T1605	T.R.F.	T.R.F.
T1605M	T.R.F.	T.R.F.
T1615	16·0	19·5
T1625	16·0	19·5
T1825	16·0	19·5
TC1004	34·65	38·15
TC1005	34·65	38·15
TC1012	34·65	38·15
TC1012F	34·65	38·15
TC1013	34·65	38·15
TCG1019	34·65	38·15
TP1009	34·65	38·15
14T2	16·0	19·5
14T3	15·75	19·25
14T3D	15·75	19·25
14T3F	15·75	19·25
14T4	15·75	19·25
14T4F	15·75	19·25
14T5	15·75	19·25
14T5F	15·75	19·25
14T6	15·75	19·25
14T6F	15·75	19·25
17K3	15·75	19·25
17K3D	15·75	19·25
17K3F	15·75	19·25
17K4	15·75	19·25

* F.M. Unit 10·7 Mc/s.

† Dual channel I.F. strip. (10·7 Mc/s for radio.)

Model	*Vision I.F. (Mc/s)*	*Sound I.F. (Mc/s)*
FERRANTI (*contd.*)		
17K4F	15·75	19·25
17K5	15·75	19·25
17K5F	15·75	19·25
17K6	15·75	19·25
17K6F	15·75	19·25
17SK4	15·75	19·25
17SK4F	15·75	19·25
17SK5	15·75	19·25
17SK5F	15·75	19·25
17SK6	15·75	19·25
17SK6F	15·75	19·25
17T3	15·75	19·25
17T3D	15·75	19·25
17T3F	15·75	19·25
17T4	15·75	19·25
17T4F	15·75	19·25
17T5	15·75	19·25
17T5F	15·75	19·25
17T6	15·75	19·25
17T6F	15·75	19·25
20T4	15·75	19·25
20T4D	15·75	19·25
20T5	15·75	19·25
20T6	15·75	19·25
21K5	15·75	19·25
21K6	15·75	19·25
22K3	15·75	19·25
24K4	15·75	19·25
24K4F	15·75	19·25
24K6	15·75	19·25
G.E.C.		
BT0124	6·0	2·5
BT302	34·65	38·15
BT303	34·65	38·15
BT304	34·65	38·15
BT305	34·65	38·15
BT306	34·65	38·15*
BT308	34·65	38·15*
BT310	34·65	38·15
BT311	34·65	38·15
BT312	34·65	38·15
BT316	34·65	38·15
BT1091A	13·5	10·0
BT1091B	13·3	9·8
BT1091C	11·3	7·8
BT1093	13·3	9·8
BT1155	34·65	38·15
BT1156	34·65	38·15
BT1252	34·65	38·15
BT1354	34·65	38·15
BT1449	34·125	37·625
BT1450	34·65	38·15
BT1746	34·125	37·625
BT1748	34·65	38·15
BT2147	T.R.F.	T.R.F.

Model	*Vision I.F. (Mc/s)*	*Sound I.F. (Mc/s)*
G.E.C. (*contd.*)		
BT2147C	T.R.F.	T.R.F.
BT2155	34·65	38·15
BT2253	34·65	38·15
BT2254	34·65	38·15
BT2448	34·125	37·625
BT2449	34·65	38·15
BT2745	34·125	37·625
BT2745R	34·65	38·15
BT2747	34·65	38·15
BT2748	34·65	38·15
BT3251	34·65	38·15
BT3252	34·65	38·15
BT3701	3·0	0·45
BT3702	3·0	0·45
BT3747	34·65	38·15
BT4541	T.R.F.	T.R.F.
BT4541C	T.R.F.	T.R.F.
BT4542	T.R.F.	T.R.F.
BT4542C	T.R.F.	T.R.F.
BT4543	34·125	37·625
BT4543C	34·125	37·625
BT4544	34·125	37·625
BT4640	13·3	9·8
BT4640C	11·3	7·8
BT4643	34·125	37·625
BT4743	34·125	37·625
BT5144	T.R.F.	T.R.F.
BT5144C	T.R.F.	T.R.F.
BT5145	T.R.F.	T.R.F.
BT5145C	T.R.F.	T.R.F.
BT5146	34·125	37·625
BT5146C	34·125	37·625
BT5147	34·125	37·625
BT5246	34·125	37·625
BT5248	34·65	38·15
BT5347	34·65	38·15
BT5348	34·65	38·15
BT5446	34·65	38·15
BT5543	34·125	37·625
BT5545	34·65	38·15
BT5642	34·125	37·625
BT5643	34·125	37·625
BT5643R	34·125	37·625
BT6145	34·125	37·625
BT6145C	34·125	37·625
BT6541	34·125	37·625
BT6541C	34·125	37·625
BT6542	34·125	37·625
BT6641	34·125	37·625
BT7092	13·5	10·0
BT7094	13·5	10·0
BT8090	3·0	0·6
BT8121	3·0	0·45
BT8149	34·65	38·15
BT8161	3·0	0·45
BT8245	34·65	38·15

* F.M. Unit 10·7 Mc/s.

Model	*Vision I.F. (Mc/s)*	*Sound I.F. (Mc/s)*
G.E.C. (*contd.*)		
BT8246	34·65	38·15
BT8249	34·65	38·15
BT8443	34·65	38·15
BT8640	34·125	37·625
BT8742	34·65	38·15
BT9121	6·0	2·5
BT9122	3·0	0·45
BT9144	13·5	10·0
BT9343	34·65	38·15
H.M.V.		
900	T.R.F.	0·46
901	T.R.F.	1·5
902	T.R.F.	0·46
902A	T.R.F.	0·46
903	9·0	5·5
904	8·0	4·5
905	8·0	4·5
907	8·0	4·5
1800	8·0	4·5
1801	8·0	4·5
1802	8·0	4·5
1803	8·0	4·5
1804	8·0	4·5
1805	T.R.F.	T.R.F.
1806	T.R.F.	T.R.F.
1807	T.R.F.	T.R.F.
1807A	T.R.F.	T.R.F.
1808	T.R.F.	T.R.F.
1811	T.R.F.	T.R.F.
1814	34·0	37·5
1815	T.R.F.	T.R.F.
1816	34·0	37·5
1820	34·0	37·5
1821	34·0	37·5
1823	34·0	37·5
1824	34·0	37·5
1824A	34·0	37·5
1825	34·0	37·5
1825A	34·0	37·5
1826	34·0	37·5
1826A	34·0	37·5
1827	34·0	37·5
1827A	34·0	37·5
1828	34·0	37·5
1829	34·0	37·5
1829A	34·0	37·5
1830	34·0	37·5
1831	34·0	37·5
1840	34·65	38·15
1841	34·65	38·15
1842	34·65	38·15
1843	34·65	38·15
1844	34·65	38·15
1845	34·65	38·15
1846	34·65	38·15

Model	*Vision I.F. (Mc/s)*	*Sound I.F. (Mc/s)*
H.M.V. (*contd.*)		
1847	34·65	38·15
1848	34·65	38·15
1850	8·0	4·5
1851	T.R.F.	T.R.F.
1854	34·65	38·15
1864	34·65	38·15
1865	34·65	38·15
1866	34·65	38·15
1867	34·65	38·15
1868	34·65	38·15
1869	34·65	38·15
1870	34·65	38·15
1871	34·65	38·15
1872	34·65	38·15*
1874	34·65	38·15
1876	34·65	38·15*
1901	8·0	4·5
1902	T.R.F.	T.R.F
1902B	T.R.F.	T.R.F
2805	34·0	37·5
2806	34·0	37·5
2807	34·0	37·5
2808	34·0	37·5
2811	34·0	37·5
2815	34·0	37·5
2851	34·0	37·5
2901	34·0	37·5
2902	34·0	37·5
2902B	34·0	37·5
3806	34·0	37·5
3807	34·0	37·5
3811	34·0	37·5
3815	34·0	37·5
3851	34·0	37·5
3902	34·0	37·5
3902B	34·0	37·5
4806	34·0	37·5
4851	34·0	37·5
4902	34·0	37·5
4902B	34·0	37·5
5806	34·0	37·5
5851	34·0	37·5
5902	34·0	37·5
5902B	34·0	37·5
INVICTA		
T101	T.R.F.	T.R.F.
T102	T.R.F.	T.R.F.
T103	T.R.F.	T.R.F.
T104	T.R.F.	T.R.F.
T105	T.R.F.	T.R.F.
T107	T.R.F.	T.R.F.
T108	T.R.F.	T.R.F.
T110	T.R.F.	T.R.F.
T111	T.R.F.	T.R.F.
T112	34·5	38·0

* F.M. Unit 10·7 Mc/s.

Model	*Vision I.F. (Mc/s)*	*Sound I.F. (Mc/s)*
INVICTA *(contd.)*		
T114	34·5	38·0
T115	34·5	38·0
T117	34·5	38·0
T118	34·5	38·0
T119	34·5	38·0
T120	34·5	38·0
118T	34·5	38·0
119T	34·5	38·0
120T	34·5	38·0
122	34·65	38·15
123	34·65	38·15
124	34·65	38·15
125	34·65	38·15
126	34·65	38·15
127	34·65	38·15
133	34·65	39·15
134	34·65	38·15
136	34·65	38·15
137	34·65	38·15
138	34·65	38·15
139	34·65	8·15
140	34·65	8·15
141	34·65	38·15
142	34·65	38·15
143	34·65	38·15
237	34·65	38·15
337	34·65	38·15
437	34·65	38·15
537	34·65	38·15
638	34·65	38·15
5370	34·65	38·15
KOLSTER-BRANDES		
CV40 ●	12·5	9·0
DV40 ●	12·5	9·0
EQ100	16·5	20·0
EV30	16·5	20·0
EV30B	16·5	20·0
EV30HM	15·9	19·4
EV30/L	16·5	20·0
EV40	16·5	20·0
EV40B	16·5	20·0
EV40HM	15·9	19·4
EV40/L	16·5	20·0
EV50 ●	12·5	9·0
FT50	16·5	20·0
FV30	16·5	20·0
FV40	16·5	20·0
HF40: Ch. 1, 4	16·5	20·0
Ch. 2, 3, 5	15·9	19·4
HF60: Ch. 1, 4	16·5	20·0
Ch. 2, 3, 5	15·9	19·4
HT60: Ch. 1, 4	16·5	20·0
Ch. 2, 3, 5	15·9	19·4
HV20: Ch, 1, 4	16·5	20·0
Ch. 2, 3, 5	15·9	19·4

Model	*Vision I.F. (Mc/s)*	*Sound I.F. (Mc/s)*
KOLSTER-BRANDES *(contd.)*		
HV40: Ch. 1, 4	16·5	20·0
Ch. 2, 3, 5	13·9	19·4
HV40F	16·0	19·5
JF40: Ch. 1, 4	16·5	20·0
Ch. 2, 3, 5	15·9	19·4
KF40	16·0	19·5
KF50: Ch. 1, 4	16·5	20·0
Ch. 2, 3, 5	15·9	19·4
KF60	16·0	19·5
KV35	16·0	19·5
KV50	16·0	19·5
LFT50	35·0	38·5
LFT60	35·0	38·5
LFT100	35·0	38·5
LVT30	35·0	38·5
LVT50	35·0	38·5
MF50	34·65	38·15
MV30	34·65	38·15
MV50	34·65	38·15
MV60	34·65	38·15
MV100	35·0	38·5
MV100/1	34·65	38·15
NF60	34·65	38·15
NF70	34·65	38·15
NF70FM	34·65	38·15
NV40	34·65	38·15
OV30	34·65	38·15
OV30FM	34·65	38·15
OV30/1	34·65	38·15
OF100	34·65	38·15
PV40	34·65	38·15
PV70	34·65	38·15
PV70FM	34·65	38·15
PV100	34·65	38·15
PV100/1	34·65	38·15
PVP20	34·65	38·15
QV20	34·65	38·15
QV20/1	34·65	38·15
QV30	34·65	38·15
QV30/1	34·65	38·15
QV70	34·65	38·15
McCARTHY		
MCC1 ●	T.R.F.	T.R.F.
MCT1 ●	T.R.F.	T.R.F.
TSH1	6·0	2·5
TSH2A	6·0	2·5
TSH2B	6·0	2·5
TSH2C	6·0	2·5
TSH212A	6·0	2·5
TSH212B	6·0	2·5
TSH212C	6·0	2·5
TSH312	6·0	2·5
TSH312/C	6·0	2·5
TSH312/T	6·0	2·5
TSH414/C	13·0	9·5
TSH414/T	13·0	9·5
TSH417	13·0	9·5

Model	*Vision I.F. (Mc/s)*	*Sound I.F. (Mc/s)*
McMICHAEL		
De Luxe: Ch. 1	13·0	9·5
Ch. 4	23·5	27·0
C52 *	24·0	27·5
C53	34·5	38·0
C54	34·5	38·0
C317	34·5	38·0
C417	34·5	38·0
C417F.M.	34·65	38·15
CR52 *	24·0	27·5
CR53	34·5	38·0
CR54	34·5	38·0
CR317	34·5	38·0
CR417	34·5	38·0
M14T	16·0	19·5
M17T	16·0	19·5
M17TLC	16·0	19·5
M21T	16·0	19·5
M21TLC	16·0	19·5
M22T	34·65	38·15
M23HFC	34·65	38·15
M71T	34·65	38·15
M72HFC	34·65	38·15
M72T	34·65	38·15
M74HFC	34·65	38·15
M74T	34·65	38·15
M274HFC	34·65	38·15
MP14	34·65	38·15
MP14DL	34·65	38·15
MP17	34·65	38·15
MP18	34·65	38·15
MP19	34·65	38·15
TM51	24·0	27·5
TM52 *	24·0	27·5
TM53	34·5	38·0
TM54A	34·5	38·0
TM54B	34·5	38·0
TM317	34·5	38·0
TM417	34·5	38·0
129L	23·5	27·0/2·0
129SC	23·5	27·0/2·0
512	24·0	27·5
512RV	24·0	27·5
909L	23·5	27·0/2·0
909SC	23·5	27·0/2·0
912L	23·5	27·0/2·0
912SC	23·5	27·0/2·0
912 Special	23·5	27·0/2·0
950L	13·0	9·5
MARCONIPHONE		
VC52A	T.R.F.	T.R.F.
VC53DA	T.R.F.	T.R.F.
VC55A	14·0	10·5
VC56DA	T.R.F.	T.R.F
VC59DA	34·0	37·5
VC60DA	34·0	37·5

Model	*Vision I.F. (Mc/s)*	*Sound I.F. (Mc/s)*
MARCONIPHONE *(contd.)*		
VC61DA	34·0	37·5
VC68DA	34·0	37·5
VC68DAM	34·0	37·5
VC69DA	34·0	37·5
VC69DAM	34·0	37·5
VC73DA	34·0	37·5
VC75A	14·0	10·5
VC76DA	34·0	37·5
VC85A	14·0	10·5
VC86DA	34·0	37·5
VC96DA	34·0	37·5
VC151	34·0	37·5
VC152	34·0	37·5
VRC52A	T.R.F	T.R.F
VRC54DA	T.R.F.	T.R.F.
VRC57DA	T.R.F.	T.R.F
VRC72A	34·0	37·5
VRC74DA	34·0	37·5
VRC77DA	34·0	37·5
VRC84DA	34·0	37·5
VRC87DA	34·0	37·5
VRC97DA	34·0	37·5
VT50A	8·0	4·5
VT53DA	T.R.F.	T.R.F
VT55A	14·0	10·5
VT56DA	T.R.F.	T.R.F.
VT59DA	34·0	37·5
VT62DA	34·0	37·5
VT63DA	14·0	10·5
VT63DA/HM	15·0	11·5
VT63DA/KS	15·0	11·5
VT63DA/L	14·0	10·5
VT63DA/M	14·0	10·5
VT63DA/N	15·0	11·5
VT63DA/S	14·0	10·5
VT63DA/W	14·0	10·5
VT64DA	34·0	37·5
VT65DA	34·0	37·5
VT68DA	34·0	37·5
VT68DAM	34·0	37·5
VT69DA	34·0	37·5
VT69DAM	34·0	37·5
VT73DA	34·0	37·5
VT75A	14·0	10·5
VT76DA	34·0	37·5
VT83DA	34·0	37·5
VT85A	14·0	10·5
VT86DA	34·0	37·5
VT150	34·0	37·5
VT151	34·0	37·5
VT153	34·65	38·15
VT155	34·65	38·15
VT156	34·65	38·15
VT157	34·65	38·15
VT158	34·65	38·15
VT159	34·65	38·15

* 23·0 Mc/s vision and 26·5 Mc/s sound for channel 2 models.

Model	*Vision I.F. (Mc/s)*	*Sound I.F. (Mc/s)*
MARCONIPHONE (*contd.*)		
VT160	34·65	38·15
VT161	34·65	38·15
701	T.R.F.	0·46
702	T.R.F.	1·5
703	T.R.F.	0·46
704	9·0	5·5
705	T.R.F.	0·46
706	8·0	4·5
707	8·0	4·5
709	8·0	4·5
710	8·0	4·5
711	8·0	4·5
712	8·0	4·5
713	8·0	4·5
MASTERADIO		
PT50	15·75	19·25
T409	T.R.F.	T.R.F.
T412	T.R.F.	T.R.F.
T509	T.R.F.	T.R.F.
T512L	T.R.F.	T.R.F.
T512M	T.R.F.	T.R.F.
T612L	T.R.F.	T.R.F.
T612M	T.R.F.	T.R.F.
TS51	15·75	19·25
TS52	15·75	19·25
TS53	15·75	19·25
TS54	15·75	19·25
TS55	15·75	19·25
T917	19·75	23·25
T918	19·75	23·25
TD4T	16·0	19·5
TD7C	16·0	19·5
TD7T	16·0	19·5
TE4C/3	16·0	19·5
TE4T	16·0	19·5
TE4T/3	16·0	19·5
TE7C	16·0	19·5
TE7C/3	16·0	19·5
TE7T	16·0	19·5
TE7T/3	16·0	19·5
TE21C	16·0	19·5
TF4T	16·0	19·5
TF7T	16·0	19·5
TF21T	16·0	19·5
TG4T	16·0	19·5
TG7C	16·0	19·5
TG7T	16·0	19·5
TG21C	16·0	19·5
TG21T	16·0	19·5
TH4T	16·0	19·5
TH7T	16·0	19·5
TH21T	16·0	19·5
TJ7T	16·0	19·5
TJ17	16·0	19·5
TJ21	16·0	99·5
TRR52	19·75	23·25

Model	*Vision I.F. (Mc/s)*	*Sound I.F. (Mc/s)*
MULLARD		
MTS389	13·2	9·7
MTS501	13·4	9·9
MTS521	13·3	9·8
MTS681	13·4	9·9
MURPHY		
A42V	4·25	0·75
A56V	4·25	0·75
A58V	4·25	0·75
V86CA	13·5	10·0
V114	13·5	10·0
V114C	13·6	10·0
V116	13·5	10·0
V118C	13·5	10·0
V120C	13·5	10·0
V134C ●	T.R.F.	T.R.F.
V136C ●	T.R.F.	T.R.F.
V150	19·0	15·5
V176C	13·5	10·0
V178C	13·5	10·0
V180C	13·5	10·0
V200	13·25	9·75
V200A	13·25	9·75
V202C	13·25	9·75
V202CA	13·25	9·75
V204	13·25	9·75
V204C	13·25	9·75
V210	13·25	9·75
V210C	13·25	9·75
V214	13·25	9·75
V214A	13·25	9·75
V216C	13·25	9·75
V216CA	13·25	9·75
V230	34·65	38·15
V240	34·65	38·15
V240A	34·65	38·15
V240C	34·65	38·15
V250	34·65	38·15
V250A	34·65	38·15
V250AD	34·65	38·15
V250C	34·65	38·15
V250CA	34·65	38·15
V270	34·65	38·15
V270A	34·65	38·15
V270C	34·65	38·15
V280	34·65	38·15
V280A	34·65	38·15
V280AD	34·65	38·15
V280C	34·65	38·15
V280CA	34·65	38·15
V290CA	34·65	38·15
V300C	34·65	38·15
V310-series	34·65	38·15
V320-series	34·65	38·15
V330-series	34·65	38·15
		6·31

Model	*Vision I.F. (Mc/s)*	*Sound I.F. (Mc/s)*
MURPHY (*contd.*)		
V410-series	34·65	38·15
V420-series	34·65	38·15
V430-series	34·65	38·15
		6·31
V440-series	34·65	38·15
		6·31
VU150	19·0	15·5
VU200A	13·25	9·75
VU210	13·25	9·75
VU210C	13·25	9·75
PAGEANT		
P50	34·65	38·15
P107	34·65	38·15
P109	34·65	38·15
PAM		
T908	16·0	19·5
T909	16·0	19·5
T952	34·5	38·0
T954	16·0	19·5
T958	34·5	38·0
500	34·65	38·15
500C	34·65	38·15
501	34·65	38·15
501A	34·65	38·15
501F	34·65	38·15
517	34·65	38·15
517A	34·65	38·15
517C	34·65	38·15
517CA	34·65	38·15
517F	34·65	38·15
521	34·65	38·15
521A	34·65	38·15
521C	34·65	38·15
521CA	34·65	38·15
521CF	34·65	38·15
521F	34·65	38·15
550	34·65	38·15
550FM	34·65	38·15
551	34·65	38·15
551FM	34·65	38·15
555FM	34·65	38·15
560F	34·65	38·15
600F	34·65	38·15
600S	34·65	38·15
606F	34·65	38·15
606S	34·65	38·15
666	34·65	38·15
680F	34·65	38·15
680S	34·65	38·15
690	34·65	38·15
750	34·65	38·15

Model	*Vision I.F. (Mc/s)*	*Sound I.F. (Mc/s)*
PAM (*contd.*)		
751	34·65	38·15
752DL	34·65	38·15
753	34·65	38·15
753C	34·65	38·15
754	34·65	38·15
755	34·65	38·15
764	34·65	38·15
765C	34·65	38·15
900	35·0	38·5
901	35·0	38·5
904	34·5	38·0
908	19·5	16·0
952	34·5	38·0
953	34·5	38·0
954	16·0	19·5
PETO SCOTT		
TR14	12·8	9·3
TR15/16	34·65	38·15
TR16	34·65	38·15
TR17	12·8	9·3
TV15/16	34·65	38·15
TV91	13·25	9·75
TV92	13·25	9·75
TV121	13·25	9·75
TV122	13·25	9·75
TV124	13·4	9·9
TV126	13·4	9·9
TV127A	13·4	9·9
TV165	13·4	9·9
TV168	13·4	9·9
TV169	13·4	9·9
TV1210	13·4	9·9
TV1411	13·4	9·9
TV1412T *	12·8	9·3
TV1414	12·8	9·3
TV1415	34·5	38·0
TV1416T	34·65	38·15
TV1418	34·65	38·15
TV1419T	34·65	38·15
TV1611	13·4	9·9
TV1711	13·4	9·9
TV1712C *	12·8	9·3
TV1712T *	12·8	9·3
TV1714	12·8	9·3
TV1715	34·5	38·0
TV1716C	34·65	38·15
TV1716T	34·65	38·15
TV1719C	34·65	38·15
TV1719T	34·65	38·15
TV1720	34·65	38·15
14SA	34·65	38·15
17SA	34·65	38·15
1422	34·65	31·15
1722	34·65	38·15

* Certain models may be 13·4 Mc/s vision and 9·9 Mc/s sound.

Model	Vision I.F. (Mc/s)	Sound I.F. (Mc/s)
PETO SCOTT (*contd.*)		
1723	34·65	38·15
1724	34·65	38·15
1725	34·65	38·15
1726	34·65	31·15
1729	34·65	38·15
1730	34·65	38·15 *
2128	34·65	38·15 *
PHILCO		
A1457	14·0	10·5
A1467	34·65	38·15
A1497	34·65	38·15
A1497A	34·65	38·15
A1557	34·65	38·15
A1707 ●	T.R.F.	T.R.F.
A1708 ●	T.R.F.	T.R.F.
A1717	14·0	10·5
A1737	14·0	10·5
A1747	14·0	10·5
A1753C	14·0	10·5
A1753T	14·0	10·5
A1757	14·0	10·5
A1767	34·65	38·15
A1777	14·0	10·5
A1787	34·65	38·15
A1800	34·65	38·15
A1800A	34·65	38·15
A1810	34·65	38·15
A1810A	34·65	38·15
A1960	34·65	38·15
A1961	34·65	38·15
A1962M	34·65	38·15
A1963	34·65	38·15
A1964	34·65	38·15
A1967	34·65	38·15
A1967M	34·65	38·15
A1968	34·65	38·15
A2160	34·65	38·15
A2161	34·65	38·15
BC1412	16·0	19·5
BC1651	16·0	19·5
BT1251	T.R.F.	T.R.F.
BT1410/3	14·0	10·5
BT1410/L	13·5	10·0
BT1412	16·0	19·5
BT1551	16·0	19·5
BT1651	16·0	19·5
BT1752	14·0	10·5
BT1752C	14·0	10·5
BT1840S	13·5	10·0
BT1840L	13·5	10·0
ST1497A	34·65	38·15
ST1800A	34·65	38·15
1000	34·65	38·15
1010	34·65	38·15

Model	Vision I.F. (Mc/s)	Sound I.F. (Mc/s)
PHILCO (*contd.*)		
1019	34·65	38·15
1020	34·65	38·15
PHILIPS		
383A	13·2	9·7
385U	13·4	9·9
463A	13·2	9·7
485U	13·4	9·9
492U	13·4	9·9
520A	13·3	9·8
563A	13·2	9·7
600A	13·4	9·9
663A	13·2	9·7
683U	13·4	9·9
704A	13·4	9·9
799A	13·3	9·8
1100U	12·0	8·5
1101U	12·0	8·5
1101UF	12·0	8·5
1114U	12·0	8·5
1114UF	12·0	8·5
1114UM	12·0	8·5
1114UMF	12·0	8·5
1115U	12·0	8·5
1115UF	12·0	8·5
1200U	12·0	8·5
1200UF	12·0	8·5
1229U	12·0	8·5
1236U	12·0	8·5
1238U	12·0	8·5
1400A	12·0	8·5
1427U	12·0	8·5
1437U	12·0	8·5
1437UF	12·0	8·5
1446U	12·0	8·5
1446U/45	12·0	8·5
1458U	34·65	38·15
1468U	34·65	38·15
1502U	13·3	9·8
1700A	13·4	9·9
1726U	12·0	8·5
1726UF	12·0	8·5
1746U	12·0	8·5
1746U/45	12·0	8·5
1747U	12·0	8·5
1748U	12·0	8·5
1756U	34·65	38·15
1757U	34·65	38·15
1758U	34·65	38·15
1768U	34·65	38·15
1772U	34·65	38·15
1778U	34·65	38·15
1792U	34·65	38·15
1796U	34·65	38·15
1800A	13·4	9·9

* Dual channel I.F. strip. (10·7 Mc/s for radio.)

Model	Vision I.F. (Mc/s)	Sound I.F. (Mc/s)
PHILIPS (*contd.*)		
2155U	34·65	38·15
2157U	34·65	38·15
2168U	34·65	38·15
2192U	34·65	38·15
2196U	34·65	38·15
2337A	12·0	8·5
2347A	12·0	8·5
6027A	12·0	8·5
6028T	12·0	8·5
PILOT		
CM54	13·5	10·0
CV34 ●	T.R.F.	T.R.F.
CV35	13·5	10·0
CV76	13·5	10·0
CV77	13·5	10·0
CV84	13·3	9·8
CV84/12	13·3	9·8
CV87	13·3	9·8
CV87/12	13·3	9·8
DDC87	13·3	9·8
DDC87/12	13·3	9·8
DDC97	34·65	38·15
DDC121	34·65	38·15
TM54	13·5	10·0
TV76	13·5	10·0
TV84	13·3	9·8
TV84/12	13·3	9·8
TV87	13·3	9·8
TV87/12	13·3	9·8
TV94	34·65	38·15
TV97	34·65	38·15
TV107	34·65	38·15
TV110F	34·65	38·15
TV111	34·65	38·15
TV117	34·65	38·15
TV120	34·65	38·15
VS9 ●	T.R.F.	T.R.F.
PORTADYNE		
OA17	34·5	38·0
T758	34·5	38·0
TA17	34·5	38·0
TC12L	14·0	10·5
TC12M	14·0	10·5
TT125	16·0	19·5
TV237	34·5	38·0
TV517	16·0	19·5
179	34·5	38·0
517	16·0	19·5
PYE		
PTV	34·65	38·15
B16T	T.R.F.	T.R.F.
B18T	T.R.F.	T.R.F.
B18T/F	T.R.F.	T.R.F.

Model	Vision I.F. (Mc/s)	Sound I.F. (Mc/s)
PYE (*contd.*)		
BV20	T.R.F.	T.R.F.
BV20C	T.R.F.	T.R.F.
BV21C	T.R.F.	T.R.F.
BV21RG	T.R.F.	T.R.F.
BV30	T.R.F.	T.R.F.
BV30C	T.R.F.	T.R.F.
BV51	T.R.F.	T.R.F.
CS17	34·65	38·15
CS17C	34·65	38·15
CS17CF	34·65	38·15
CS17F	34·65	38·15
CTL21CVS	34·65	38·15
CTL58F	34·65	38·15
CTL58S	34·65	38·15
CTL58VS	34·65	38·15
CTM4	34·65	38·15
CTM17F	34·65	38·15
CTM17S	34·65	38·15
CTM17/S	34·65	38·15
CTM17T	34·65	38·15
CTM21	34·65	38·15
CTM21CD	34·65	38·15
CTM21F	34·65	38·15
CTM21/F	34·65	38·15
CTM21S	34·65	38·15
CW17	34·65	38·15
CW17C	34·65	38·15
CW17CF	34·65	38·15
CW17CS	34·65	38·15
CW17F	34·65	38·15
CW17S	34·65	38·15
CW21F	34·65	38·15
CW21S	34·65	38·15
CY58CVS	34·65	38·15
D16T	T.R.F.	T.R.F.
D18T	T.R.F.	T.R.F.
D18T/F	T.R.F.	T.R.F.
FV1	35·0	38·5
FV1C	35·0	38·5
FV2C	35·0	38·5
FV4C	35·0	38·5
FV4CDL	35·0	38·5
LB17NF	34·65	38·15
LV20	T.R.F.	T.R.F.
LV21C	T.R.F.	T.R.F.
LV21RG	T.R.F.	T.R.F.
LV30	T.R.F.	T.R.F.
LV30C	T.R.F.	T.R.F.
LV51	T.R.F.	T.R.F.
PV110	34·65	38·15
RTL17	34·65	38·15
SP17	34·65	38·15
SP17LB	34·65	38·15
V2	16·0	19·5
V4	16·0	19·5
V4C	16·0	19·5
V7	16·0	19·5

Model	*Vision I.F. (Mc/s)*	*Sound I.F. (Mc/s)*	*Model*	*Vision I.F. (Mc/s)*	*Sound I.F. (Mc/s)*
PYE *(contd.)*			**R.G.D.** *(contd.)*		
V7CD	16·0	19·5	L2350	13·0	9·5
V7ODL	16·0	19·5	L2351	T.R.F.	T.R.F.
V14	34·65	38·15	L2751	13·0	9·5
V14O	34·65	38·15	T14	34·65	38·15
V17RG Trio	34·65	38·15	179	13·0	9·5
V17RM	34·65	38·15	180	13·0	9·5
V110	34·65	38·15	189	13·0	9·5
V200	34·65	38·15	190	13·0	9·5
V200LB	34·65	38·15	502	34·65	38·15
V300F	34·65	38·15	502A	34·65	38·15
V300S	34·65	38·15	600	34·65	38·15
V310F	34·65	38·15	605	34·65	38·15
V310S	34·65	38·15	1455T	16·0	19·5
V400	34·65	38·15	1456T	16·0	19·5
VO9	16·0	19·5	1755O	16·0	19·5
VT2	16·0	19·5	1755T	16·0	19·5
VT4	34·65	38·15	1756O	16·0	19·5
VT7	16·0	19·5	1756T	16·0	19·5
VT7CD	16·0	19·5	1757O	16·0	19·5
VT7ODL	16·0	19·5	1800	13·0	9·5
VT17	34·65	38·15	2349T	13·0	9·5
VT17CD	34·65	38·15	6012T	14·0	10·5
VT17CDL	34·65	38·15	6014T *	14·0	10·5
VT21O	34·65	38·15	6014/3T	34·0	37·5
VT21CD	34·65	38·15	6015T	14·0	10·5
17TCDL	34·65	38·15	6017T	14·0	10·5
815	T.R.F.	T.R.F.	6017/3T	34·0	37·5
816	T.R.F.	T.R.F.	7015T	14·0	10·5
817	T.R.F.	T.R.F.	7015O	14·0	10·5
819	T.R.F.	T.R.F.	7017O *	14·0	10·5
828	T.R.F.	T.R.F.	7017/3O	34·0	37·5
830	T.R.F.	T.R.F.			
838	T.R.F.	T.R.F.	**RAYMOND**		
843	T.R.F.	T.R.F.	F49	T.R.F.	T.R.F.
4045	T.R.F.	T.R.F.	F49B	T.R.F.	T.R.F.
4046	T.R.F.	T.R.F.	F53	13·5	10·0
			F53B	14·0	10·5
R.G.D.			F54B	14·0	10·5
"Deep 17"	34·65	38·15	F56	34·75	38·25
Deep 17A	34·65	38·15	F60	34·75	38·25
Deep 17CA	34·65	38·15	F61	34·75	38·25
"The 17"	16·0	19·5	F79P F65	34·75	38·25
"The 21"	34·65	38·15	F79P/O	34·75	38·25
B1700	13·0	9·5	F93	34·75	38·25
B1800	13·0	9·5	F100	34·75	38·25
B2350	13·0	9·5	F100C	34·75	38·25
B2351	13·0	9·5	F104	34·75	38·25
B2351T	13·0	9·5	F105	34·75	38·25
B2751	13·0	9·5	F105/1	34·75	38·25
C54 *	14·0	10·5	F107	34·75	38·25
C55	16·0	19·5			
H1700	13·0	9·5	**REGENTONE**		
H1800	13·0	9·5	Big 12: Ch. 1	13·5	10·0
H2351	13·0	9·5	Ch. 4	14·0	10·5
L1700	13·0	9·5	Big 12B	14·0	10·5
L1800	13·0	9·5	Big 12H	14·0	10·5

* In some special areas, vision is 15·0 Mc/s and 11·5 Mc/s sound.

Model	*Vision I.F. (Mc/s)*	*Sound I.F. (Mc/s)*	*Model*	*Vision I.F. (Mc/s)*	*Sound I.F. (Mc/s)*
REGENTONE *(contd.)*			**SOBELL** *(contd.)*		
Big 12L	14·0	10·5	T121	13·0	9·5
Big 12/5	14·0	10·5	T122	13·0	9·5
Big 15/5	14·0	10·5	T143	16·0	19·5
Big 15/5O	14·0	10·5	T143O	16·0	19·5
T15B	14·0	10·5	T144	16·0	19·5
T15H	14·0	10·5	T145	34·5	38·0
T15K	14·0	10·5	T171	16·0	19·5
T15L	13·5	10·0	T171O	16·0	19·5
T15 Mk. 2B	14·0	10·5	T172	34·65	38·15
T15 Mk. 2H	14·0	10·5	T174	16·0	19·5
T15 Mk. 2L	14·0	10·5	T174O	16·0	19·5
T21	34·65	38·15	T174LO	16·0	19·5
T21FM	34·65	38·15	T175	34·5	38·0
T21 Mk 11	34·65	38·15	T175O	34·5	38·0
T176	34·65	38·15	T175LO	34·5	38·0
T177	34·65	38·15	T176	34·65	38·15
TEN-4	34·65	38·15	T176O	34·65	38·15
TEN-5	34·65	38·15	T176LO	34·65	38·15
TEN-8	34·65	38·15	T178	34·65	38·15
TEN-12	34·65	38·15	T17	34·65	38·15
TR20B	13·5	10·0	T191	34·65	38·15
TR20L	13·5	10·0	T224	16·0	19·5
TR177	34·65	38·15	T225	16·0	19·5
TT7	16·0	19·5	T227	16·0	19·5
14T *	14·0	10·5	T274	16·0	19·5
17O *	14·0	10·5	T277	16·0	19·5
17OOMB *	14·0	10·5	T278	34·65	38·15
17T *	14·0	10·5	T292	34·65	38·15
143C	34·0	37·5	T346	16·0	19·5
143T	34·0	37·5	T347	16·0	19·5
153T	34·0	37·5	T348	34·65	38·15
153XT	34·0	37·5	T1291	13·5	10·0 †
173C	34·0	37·5	TPS147	34·65	38·15
173COMB	34·0	37·5	TPS147DL	34·65	38·15
173T	34·0	37·5	TPS173	34·65	38·15
174T	16·0	19·5	TPS180	34·65	38·15
183T	34·0	37·5	TPS187	34·65	38·15
317O	34·0	37·5	TRG174	16·0	19·5
317T	34·0	37·5	TRG175	34·5	38·0
			TS14S	16·0	19·5
SOBELL			TS17	16·0	19·5
SC24	34·65	38·15			
SC270	34·65	38·15	**SPENCER-WEST**		
T21	16·0	19·5	Teevy	34·65	38·15
T21O	16·0	19·5	TV17	34·65	38·15
T21LO	16·0	19·5	TV173R	34·65	38·15
T22	34·65	38·15	TV958	34·65	38·15
T23	34·65	38·15	17	34·65	38·15
T24	34·65	38·15	171	34·65	38·15
T87 ●	T.R.F.	T.R.F.	172	34·65	38·15
T89L	T.R.F.	T.R.F.	173R	34·65	38·15
T90	13·0	9·5	174	34·65	38·15
T91	13·0	9·5	175	34·65	38·15
T107 ●	T.R.F.	T.R.F.	176	34·65	38·15
T120	13·5	10·0 †	178	34·65	38·15

* Or 15·0 Mc/s vision and 11·5 Mc/s sound.
† 14 Mc/s vision and 10 5 Mc/s sound for Birmingham models.

Model	*Vision I.F. (Mc/s)*	*Sound I.F. (Mc/s)*
SPENCER-WEST (*contd.*)		
180	34·65	38·15
181	34·65	38·15
957	34·65	38·15
958	34·65	38·15
STELLA		
ST1480U	13·4	9·9
ST1481A	12·0	8·5
ST1500U	12·0	8·5
ST1522U	13·4	9·9
ST2717U	34·65	38·15
ST5721U	34·65	38·15 *
ST6414U	12·0	8·5
ST6414U/45	12·0	8·5
ST6417U	12·0	8·5
ST6417U/45	12·0	8·5
ST6917U	34·65	38·15 *
ST6921U	34·65	38·15 *
ST8314U	12·0	8·5
ST8314UF	12·0	8·5
ST8317U	12·0	8·5
ST8514U	34·65	38·15
ST8517U	34·65	38·15
ST8617U	34·65	38·15 *
ST8621U	34·65	38·15 *
ST8917U	34·65	38·15 *
ST8921U	34·65	38·15 *
ST9212U	12·0	8·5
STRAD		
RMT717	16·0	19·5
ULTRA		
D57 series †	10·7	7·2
D70 series	19·5	16·0
T22	5·8	2·3
T24	5·8	2·3
V8–14	34·5	38·0
V8–15	34·5	38·0
V8–17	34·5	38·0
V14–53	34·65	38·15
V15–60	34·5	38·0
V17–50A	34·65	38·15
V17–50B	34·65	38·15
V17–60	34·5	38·0
V17–63	34·65	38·15
V17–70	34·65	38·15
V21–70	34·65	38·15
V47 series †	19·5	16·0
V60 series	19·5	16·0
V71 series	19·5	16·0
V80 series:		
Ch. 1, 2, 4, 5	19·5	16·0
Ch. 3	18·0	14·5

Model	*Vision I.F. (Mc/s)*	*Sound I.F. (Mc/s)*
ULTRA (*contd.*)		
V84 series:		
Ch. 1, 2, 4, 5	19·5	16·0
Ch. 3	18·0	14·5
VA72 series:		
Ch. 1, 2, 4, 5	19·5	16·0
Ch. 3	18·0	14·5
VP14–53	34·65	38·15
VP17–72	34·65	38·15
VP21–72	34·65	38·15
VR17–52	34·65	38·15
VR17–62	34·65	38·15
VR17–71	34·65	38·15 ‡
VR21–71	34·65	38·15 ‡
VT8–14	34·5	38·0
VT8–15	34·5	38·0
VT9–15	34·5	38·0
VT9–17	34·5	38·0
W8–17	34·5	38·0
W17–60	34·5	38·0
W21–60	34·5	38·0
W47 series †	10·7	7·2
W57 series †	10·7	7·2
W70 series	19·5	16·0
W72 series	19·5	16·0
W80 series:		
Ch. 1, 2, 4, 5	19·5	16·0
Ch. 3	18·0	14·5
W84 series:		
Ch. 1, 2, 4, 5	19·5	16·0
Ch. 3	18·0	14·5
W817	34·5	38·0
WR17–52	34·65	38·15
WR17–62	34·65	38·15
WR21–62	34·65	38·15
WT9–17	34·5	38·0
Y72 series	19·5	16·0
Y73 series	19·5	16·0
Y84 series:		
Ch. 1, 2, 4, 5	19·5	16·0
Ch. 3	18·0	14·5
YA72 series:		
Ch. 1, 2, 4, 5	19·5	16·0
Ch. 3	18·0	14·5
YA73 series:		
Ch. 1, 2, 4, 5	19·5	16·0
Ch. 3	18·0	14·5
YE73 series:		
Ch. 1, 2, 4, 5	19·5	16·0
Ch. 3	18·0	14·5
VIDOR		
CN369	13·0	9·5
CN369A	13·1	9·0
CN370	9·75	6·25

* Sound I.F.T.s tuned to 38·35 Mc/s.
† London models aligned to upper sideband.
‡ F.M. sub-unit 10·7 Mc/s.

Model	*Vision I.F. (Mc/s)*	*Sound I.F. (Mc/s)*
VIDOR (*contd.*)		
CN377	9·75	6·25
CN390	9·75	6·25
CN391	9·75	6·25
CN405	9·75	6·25
CN406	9·75	6·25
CN4201	9·75	6·25
CN4202	9·75	6·25
CN4206	9·75	6·25
CN4207	9·75	6·25
CN4208	9·75	6·25
CN4209	9·75	6·25
CN4212	9·75	6·25
CN4213	16·0	19·5
CN4215	16·0	19·5
CN4216	16·0	19·5
CN4217	16·0	19·5
CN4218	16·0	19·5
CN4220	16·0	19·5
CN4221	16·0	19·5

Model	*Vision I.F. (Mc/s)*	*Sound I.F. (Mc/s)*
VIDOR (*contd.*)		
CN4225	16·0	19·5
CN4226	16·0	19·5
CN4228	16·0	19·5
CN4229	16·0	19·5
CN4230	34·65	38·15
CN4231	34·65	38·15
WHITE IBBOTSON		
Mark 1	14·0	10·5
Mark 2	14·0	10·5
1612: Ch. 1, 2, 4	14·0	10·5
Ch. 3, 5	15·25	11·75
2015: Ch. 1, 2, 4	14·0	10·5
Ch. 3, 5	15·25	11·75
2418: Ch. 1, 2, 4, 5	14·0	10·5
Ch. 3	15·25	11·75
4836: Ch. 1, 2, 4	14·0	10·5
Ch. 3, 5	15·25	11·75

Note: Intermediate frequencies are now generally 34·65 Mc/s (vision) and 38·15 Mc/s (sound). Where, as shown in the Table, manufacturers have adopted these frequencies, it can usually be assumed that these will be retained for later models.

Switch Tuner Alignment

The tuner should be connected as set out for the turret tuner.

For setting the oscillator, start at Channel 13 and work down the coils to Channel 1.

If one coil does not have enough adjustment, it will be necessary to return to Channel 13 (for Band III) or Channel 5 (for Band I) and make a new start.

The anode, R.F. anode and mixer grid circuits should be commenced at Channel 13 by adjusting L9, L11 and L27 (Fig. 7) for the best curve shape.

FIG. 12.—PORTABLE RECEIVER TESTER MODEL TF888/3.

This equipment combines a wide-range signal generator (70 kc/s to 70 Mc/s) with internal and external amplitude modulation, a tone source of variable level and an audio-frequency power meter, in a compact assembly.

(*Marconi Instruments Ltd.*)

Now tune down to Channel 6 and, if the curve is unsatisfactory, adjust C7, C12. Repeat until Channels 6–13 inclusive are satisfactory.

Now set up Channel 5 with L7, L13 and L22. Check channels 5–1. If unsatisfactory, it will be necessary to pinch up or stretch out the little coils round the periphery of the switch wafers until the curve is correct. When this is done always check the channels below the one adjusted.

Always set up the aerial circuit for maximum gain at the mid-frequency.

The A.G.C. lead from the R.F. Grid should be earthed if no contrary instructions are stated.

Miscellaneous Information

A further point in the use of a sweep generator is that it may be possible to see the response of the tuned circuits individually in

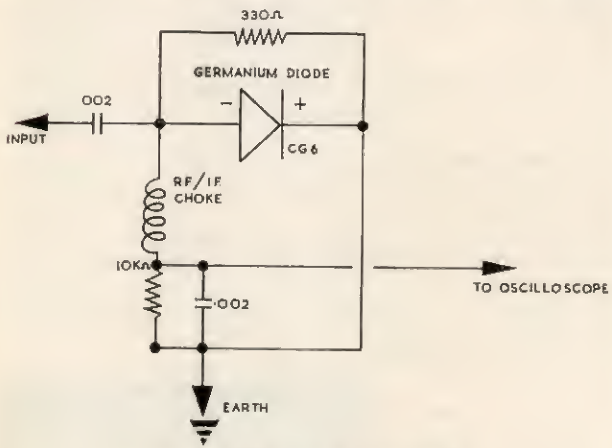


FIG. 13.—ANODE DAMPING DEVICE.

case of need. To do this, connect a detector made up compactly to the circuit of Fig. 13 to the anode of the valve following the circuit under test and connect the wobbulator to the preceding grid.

[SECTION 14]

CATHODE-RAY TUBES

by A. G. THOMSON, B.Sc.(Eng.), A.M.I.E.E.

AT one stage, almost all cathode-ray tubes used in television receivers employed magnetic deflection and focusing of the electron beam. In recent years, however, there has been a trend towards electrostatic focusing, thus eliminating the external magnets and making the tube easier to set up.

Fig. 1 shows the arrangement of a tetrode tube with magnetic focusing. Electrons are emitted by the indirectly-heated cathode K and are attracted by the first anode A_1, which is usually 150–300 V positive with respect to the cathode. A_1 consists of a skirted disc with a small central hole through which most of the electrons pass up the tube to strike the fluorescent screen S, which is composed of "phosphors" that emit light under electron impact (*e.g.*, zinc sulphide, blue; or zinc cadmium sulphide, yellow). To obtain an approximation to white light, mixtures of phosphors are often used. Surrounding the cathode is the cup-shaped grid G, also with a small central hole. An electric field is produced between grid and cathode by virtue of their potential-difference, and this controls the number of electrons drawn through the first anode—and hence the brightness of the spot. A grid voltage 25–100 V negative to cathode will cut off the electron flow altogether. The second anode, A_2, con-

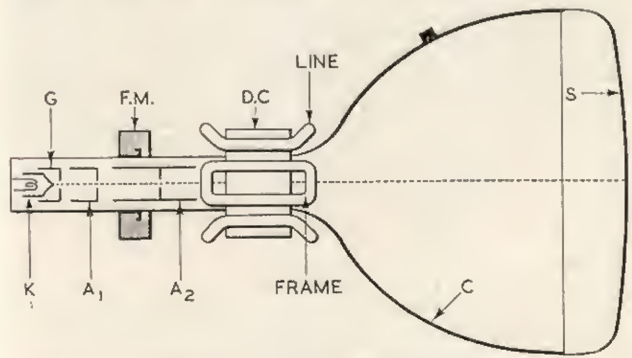


FIG. 1.—ARRANGEMENT OF A TYPICAL TETRODE CATHODE-RAY TUBE.

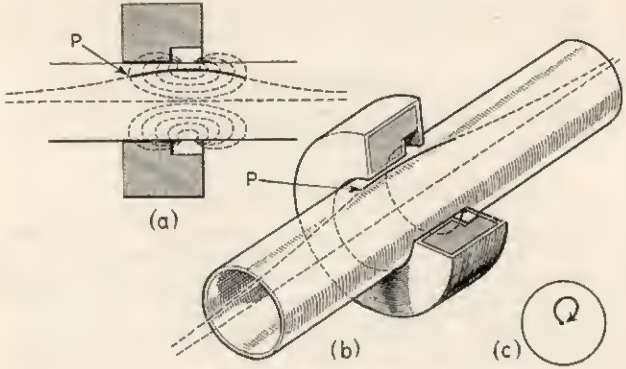


FIG. 2.—FOCUSING BY SHORT COIL.
(c) Shows an end view of the electron path.

nected internally to the graphite coating C inside the wall, gives further acceleration and governs the final electron velocity: its voltage is 6–16 kV (20–50 kV in projection models), determining the ultimate possible brightness of the screen fluorescence.

Focusing

The electrons, travelling at high velocity, must be focused to a small spot, *e.g.*, 25 thousandths of an inch in diameter on a 14-in. tube. Now a flow of electrons, whether in a wire or not, is a current; and when a current flows across a magnetic field, it experiences a force which tends to move it. In the cathode-ray tube the electron stream thus experiences the deflecting force when passing across a magnetic field. By means of a short coil, or a permanent-magnet arrangement, a field, as shown in Fig. 2 (*a*), is produced. Electrons passing along the tube axis do not cross this field, and so are unaffected, but those entering at P are deflected into a helical path whose radius is proportional to the strength of the field, and whose pitch is proportional to the *tangential* velocity of the electrons. Since the *axial* velocity is not affected by the magnetic field, all electrons may be brought to a focus on the screen in a spot corresponding to the origin—the cathode. It is thus important for the cathode to be small so that the focused spot is well defined.

Deflection

The spot must be made to transverse the screen rapidly from side to side and more slowly from top to bottom to produce the "raster". For line scanning a varying magnetic field is required which varies linearly to deflect the spot left-to-right and then rapidly right-to-left. Simultaneously, there must be a

corresponding top-to-bottom and return motion for frames. D.C in Fig 1, shows the deflecting coils: the deflection is at right angles to the direction of the magnetic field, so that the vertically-disposed field is that of the line-deflection coils. In this way the spot will trace out the "raster", which corresponds to the pattern traced by the camera tube.

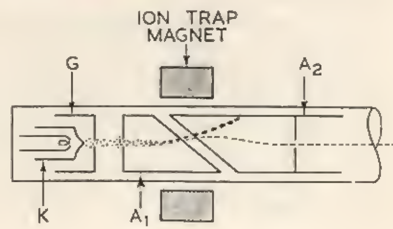
Modulation

To reproduce the "picture" as seen by the camera, the instantaneous brightness of the spot is modulated by the instantaneous variation of the cathode-grid potential from its mean or quiescent value, determined by the "brilliance" control. This may be done either by driving the grid positive with respect to the cathode, or by applying a negative-going signal to the cathode.

Ions

In addition to the electrons, positively and negatively charged ions are also produced in the cathode-ray tube. The former are attracted to the grid and cathode, but the latter travel to the fluorescent screen. They are between 5,000 and 500,000 times heavier than electrons, and though like electrons they are attracted by the first and second anodes, they are much less deflected by magnetic fields. The deflection of electric particles by a magnetic field is directly proportional to the strength and the length of the deflecting field and its distance from the screen, and inversely proportional to the particle velocity. But the latter varies as the square root of the quotient of the final anode voltage and particle mass: hence the heavy negative ions are less deflected, and they destroy the fluorescent property of the screen by bombardment over a small central area. The result is a dark spot referred to as "ion-burn". Ion-burn may be avoided by removing the ions from the beam, either by passing the beam through an electrical and then a magnetic field so that the ions are deflected in the first and not in the second (see Fig. 3) or by a "bent-gun" in which the beam is initially projected at about 10° to the tube axis and an "ion-trap" magnet deflects the electrons back to the tube axis. The ions, however, carry nearly straight on to the second anode (see Fig. 4).

FIG. 3.—"UNDEFLECTED BEAM" TYPE OF ION TRAP.



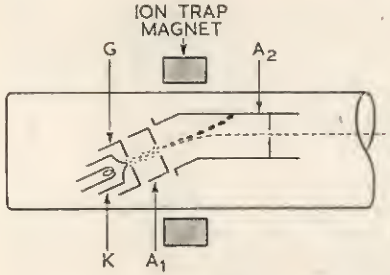


FIG. 4.—" BENT-GUN " TYPE OF ION TRAP.

A different treatment of the problem is to prevent the ions in the beam from reaching the fluorescent material by backing it with a very thin metallic film. Aluminium is the usual metal, and considerable success in reducing ion-burn has attended "aluminising", which was originally introduced mainly to improve brightness and contrast. In some modern tubes both methods of reducing ion-burn are used.

Because of the thinner stem used to reduce the power needed in the deflection coils, bent-gun ion traps are not fitted in 110° deflection tubes, and these are usually aluminium backed.

Aluminising

In a non-backed tube about half the light is visible at the front of the phosphor. The remainder appears at the back, and even with an internal graphite coating some of this light is reflected back to the screen, where it reduces contrast by faintly illuminating the whole screen. With aluminising, the useful output is increased, as the aluminium film reflects the backward output, improving both brightness and contrast. For maximum efficiency the thickness of the aluminising film is closely related to the final E.H.T. voltage, so that the indiscriminate fitting of an aluminised tube may not result in any noticeable improvement in performance.

Tinted Screens

Dark- or tinted-glass screens have also been introduced to improve picture contrast when viewing in strong ambient light. Ambient light illuminates the " black " portions of the screen and reduces contrast. With tinting, the small loss of brightness (as the phosphor is seen through the tinted glass) is compensated by increasing the brilliance control. The " black-level " seen by the viewer is determined by the ambient light reflected from the screen, and as this has to pass through the tinted glass twice (once to reach the phosphor and once to reach the viewer) the result is a darker " black " and improved contrast. A.G.T.

Multi-electrode Guns and Electrostatic Focusing

The guns in most early picture tubes were of either triode or tetrode design, but recently pentode, hexode and heptode types have also become popular. These offer the advantage that a smaller beam diameter can be produced in the region of the deflection coils, making for more uniform focusing over the entire area of the screen. In earlier tubes there was often a tendency towards " deflection defocusing " at the edges of the screen.

Another change of considerable importance is the introduction of electrostatically focused tubes, in place of permanent-magnet or electromagnetic focusing. The electrostatically-focused tube not only eliminates the focus magnet, with its problems of adjustment and mounting, but also reduces assembly and setting-up time. It also means that a potentiometer-type focus control can be fitted, but, as this method of focusing seldom requires subsequent readjustment, it is sometimes referred to as " auto focus " and is adjusted by altering the connection of the focusing electrode to the tube base, permitting a choice between the fixed potentials represented by " chassis ", the normal H.T. line and the " boosted H.T." line.

Wide-angle Deflection Tubes

The length of the picture tube is the main factor in determining the depth of the receiver cabinet, and considerable reduction in cabinet size for a given size of picture has been made possible by increasing the deflection angle of the electron beam. In early tubes this angle was often about 50°, requiring a long bulbous section of tube, but the angle has been progressively increased, first to about 70°, then to 90° and most recently to 110°. The overall length of a modern 21-in. tube is thus less than that of an early 9-in. tube.

The main disadvantage of the wide-angle deflection tube is the greater scanning power required, although increases in the efficiency of scanning components and new circuit techniques can provide the extra power without unduly adding to the power dissipation of the time-bases.

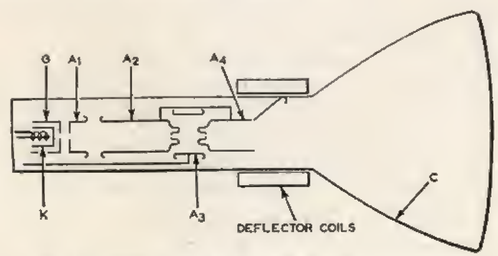


FIG. 5.—TYPICAL TUBE USING ELECTROSTATIC FOCUSING.

One means of making a given amount of scan power more effective is to place the deflection coils nearer to the electron beam, and the necks of 110° tubes are narrower than for earlier tubes. For this reason, these tubes have a smaller eight-pin base, known as the B8H. Since these pins are more readily damaged than with B12A bases, care should be taken when removing or replacing the socket.

With 110° tubes, which are usually more rounded than the smaller-deflection-angle types, it is common practice to fit a 5 : 4 aspect ratio mask, and then to set up the receiver with some horizontal overscan.

Handling Cathode-ray Tubes

Although the danger of implosion when handling tubes is relatively slight, provided that care is taken not to let the neck strike the chassis or service bench, it *can* occur, and it is advised that precautions to guard against the effects of such an implosion should always be taken. The high vacuum of tubes means that the pressure on the envelope is very high, amounting to more than a ton for relatively small tubes. When a tube is dropped or comes into sharp contact with some other object, the glass may shatter, and be spread in all directions at high velocity. It is therefore highly advisable to wear gloves at all times when handling tubes, while protective goggles will give an added sense of security.

The tube should always be lifted and carried by placing one hand beneath the face, this hand taking the weight and fulfilling the lifting action. The other hand should be placed on the flare to steady the tube. This avoids placing any strain on the junction between the cone and the neck, which is mechanically the weakest part of the tube. With metal-cone tubes, the supporting hand must be beneath the face and not merely hooked under the lip, as this would impose a strain between the glass face and the metal cone.

The tube must never be placed face downwards on the bare surface of a bench, as this is likely to cause scratches which will mar the picture. It is best to place the tube on a piece of felt or other thick material, or, failing this, a few sheets of paper.

The risk of implosion is greatly increased if the glass surface is scratched or if the rim of a metal cone is knocked. It should also be remembered that the internal and external coatings of many tubes form a condenser, and if the tube is handled when this is in a charged condition, it is possible to receive a shock sufficiently strong to induce the recipient to drop the tube; this risk can be eliminated by always connecting the final anode to the external coating when the tube is removed from its socket. Also, to touch this coating with damp hands will impair its insulating properties.

Viewers should be protected from implosion by a strong glass or plastic screen : suitable screens include $\frac{1}{4}$-in. armour-plate glass (not ordinary plate glass) or $\frac{3}{16}$-in.-thick flat perspex sheet.

In time, a film of dust will be formed on the face of the tube by electrostatic attraction. This can be removed by wiping with a soft, slightly moistened cloth, after which it must be dried thoroughly. Anti-static preparations may be used, but the makers' instructions should be carefully followed.

When refitting, never use force when inserting the tube into the deflection yoke and focus coil, and take care not to tighten the tube straps and clamps excessively : remember that while this might not by itself cause the tube to break, a tube subjected to excessive clamp pressure is much more liable to break should it be accidentally struck.

Replacing Cathode-ray Tubes

One result of the rapid development of television picture-tube technique has been the multiplicity of types used during the past few years; it also raises the question of replacing the older types of tubes, when they wear out, by more modern designs. In particular, the service engineer is frequently called upon to decide whether it is advisable to replace the original tube with one fitted with an ion trap. In general, the following questions must be answered before a decision can be made :

(1) Is there sufficient space for the ion-trap magnet ?

(2) Are there any iron parts close to the cathode-ray tube that may affect the field of the ion trap ?

Two other factors also have to be taken into account when substituting new types of cathode-ray tubes. Many current tubes have their external surface coated with Aquadag, which is intended to form part of the E.H.T. smoothing filter. If a non-coated tube is replaced by a coated tube, it is essential that the coating be connected to chassis; otherwise the coating will attain a high positive charge and be a source of danger. Difficulty may also occasionally be experienced in fitting a new tube in an old-type mask; this is because new production methods result in there being a slight difference in the finish of the cathode-ray tube where the face and flare meet.

PICTURE-TUBE SALVAGE

The replacement of a picture tube represents a considerable item of expenditure to the average owner, and service engineers are often asked if they can avoid the need to purchase a new tube, even at some cost to picture quality.

Makeshift repairs are often inadvisable, as any temporary improvement may soon be reversed, with the result that a new tube has to be purchased after all, and money spent on extending the life of the original tube will have been wasted. There are, nevertheless, several methods of picture-tube salvage which have become fairly well established in practice, and often give reasonably satisfactory results for a worth-while period.

Low-emission Tubes

Where the picture has become "fuzzy" with little contrast or brilliance and with a tendency to turn negative when either of these controls is advanced, this is often a sign of low emission. Two methods of temporary rejuvenation of the cathode emission, provided that the tube is still "hard", are fairly widely used, although in both systems it should be clearly recognised that there is the risk of the attempted "cure" causing the complete breakdown of the heater.

The first is to run the tube for a short period with the heater considerably over-run and with all other voltages removed (sometimes a potential of about 100 volts is put on the grid), by means of a tapped transformer or auto-transformer. The other method, which is probably more widely used, is to install a permanent "boost" transformer or auto-transformer providing from 20 to 50 per cent additional heater voltage. The installation of a boost transformer has frequently extended the useful life of tubes by many months, particularly with the older type of low-voltage heater, although in other cases the life may be prolonged for only a short period; the extra life averages roughly about four to six months.

Electrode Short-circuits and Miscellaneous Faults

Heater–cathode short-circuits, often of an intermittent nature, are not infrequent, and may result in flashing, uncontrollable brilliance, hum bars or absence of raster. Where a heater–cathode short-circuit has been traced, isolating transformers, which are specially made for this application and which are now readily available, provide a means of extending the useful life of the tube. Such transformers must have a very low inter-winding capacitance, as otherwise there will be considerable loss of high-frequency video signals (which, with the heater–cathode short-circuit, will appear on the heater line) and hence deterioration of picture quality. The use of an isolating transformer is, of course, practicable only on A.C. mains. With the aid of an isolating transformer, tubes with heater–cathode short-circuits can often be used quite successfully for relatively long periods; in fact, there is little evidence that the life of a defective tube fitted with an isolating transformer differs appreciably from that of a normal tube.

Similar fault symptoms may sometimes be traced to grid-cathode short-circuits. Where the tube has a tetrode gun, it is possible, though often at some cost to picture quality, to strap the grid to the cathode and then to rewire the tube with the first anode acting as control grid.

Intermittent inter-electrode short-circuits often occur only when the tube is at full operating temperature and can sometimes be eliminated by slightly lowering the heater voltage; a simple method with series-connected tubes is to wire a suitable resistor in parallel with the heater of the tube.

It is worth noting that premature tube failures and inter-electrode short-circuits are frequently caused by the over-running of the heater and consequent high cathode temperature. It is recommended, when replacing a faulty tube, to check the heater *voltage* in a parallel-fed receiver and to check the heater *current* in a series-fed receiver. Measurements should be made after checking that the mains-tapping is correctly adjusted. Currents should be within 5 per cent of the rated figure and voltages within 7 per cent.

A picture-tube fault that may occasionally develop in fairly new tubes is a change in the grid cut-off characteristics; this may result in excessive brilliance even with the brilliance control set at minimum. This type of fault can sometimes be overcome by adjusting bias levels; sometimes by simply connecting a high-value resistor (*e.g.*, 10M) between the first anode and chassis.

Scratched tube faces can often be repolished by the tube manufacturers provided that the scratches are not too deep.

Although not strictly speaking a picture-tube fault, it is worth noting that as picture tubes age any deficiency in E.H.T. voltage tends to produce results akin to that of a "soft" tube or failing emission, and before deciding that a tube has no further useful life it is advisable to check the E.H.T.

In addition to such work, there are now a number of firms who specialise in salvage work for the trade. This includes fitting new cathode assemblies after opening the tube; or alternatively re-activating the cathode followed by a re-vacuuming process by heating the "getter" with an R.F. heater.

Correct Usage of Cathode-ray Tubes

A British Standards code of practice (C.P. 1005 : 1954) on the use of cathode-ray tubes makes the following recommendations on how to secure optimum performance and life :

Manufacturers' ratings should never be exceeded.

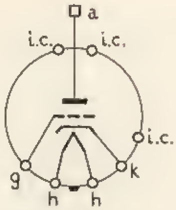
Heater voltage should not vary more than 5 per cent from the rated value; low voltages are as much to be avoided as high voltages. Series connection of heaters should be avoided (this does not apply to certain modern tubes specifically designed for such operation).

Television tubes which are designed to operate in a series heater chain should have the heater current restricted to 2·5 per cent of the rated value.

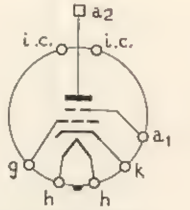
Before applying a potential between the heater and cathode of a tube, the manufacturer's tube specification should be studied. If no maximum voltage is given it is better to restrict this value to the minimum possible, preferably less than 5 volts.

When the tube is mounted horizontally, the correct method is to support the tube near the bulb at its maximum diameter and also to clamp the neck lightly near, but not actually on, the base. The fixing should be resilient, and metal-to-glass clamps avoided.

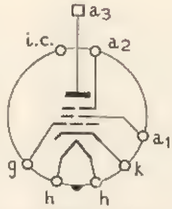
(*Continued on page 237*)



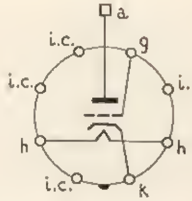
DUODECAL B12A
TRIODE CONNECTIONS
(1)



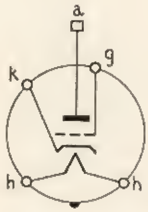
DUODECAL B12A
TETRODE CONNECTIONS
(2)



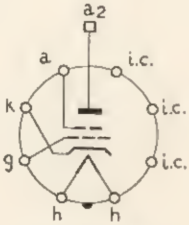
DUODECAL B12A
PENTODE CONNECTIONS
(3)



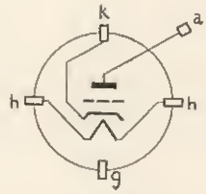
INTERNATIONAL OCTAL K
(4)



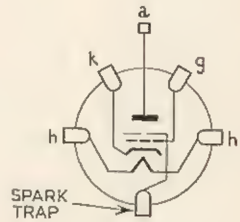
MAZDA OCTAL
(5)



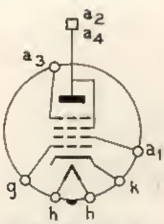
LOCTAL B8G
(6)



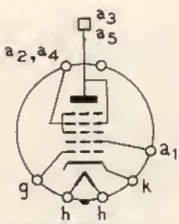
4–CLIP
(7)



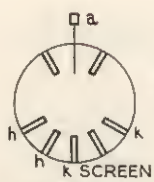
SIDE CONTACT
(8)



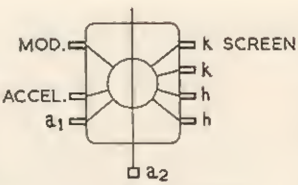
DUODECAL B12A
HEXODE CONNECTIONS
(9)



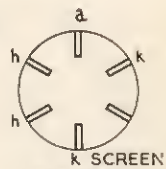
DUODECAL B12A
HEPTODE CONNECTIONS
(10)



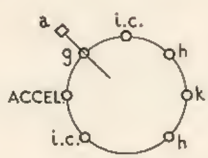
SIDE WIRE
TYPES 3/3, 3/4, 3/5, 3/6A



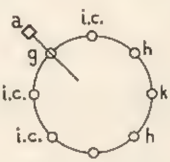
7–PIN SPLIT BASE
TYPES 6/5, 6/6



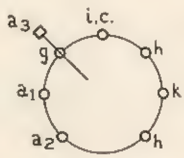
SIDE WIRE
TYPES 3/1, 3/2



7–PIN (1)

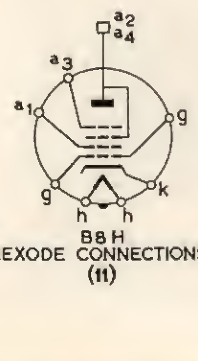


7–PIN (2)



7–PIN (3)

The Six Diagrams Above Show Types of Base and Pin Connections for Emiscope Cathode-ray Tubes.



B8H
HEXODE CONNECTIONS
(11)

TABLE 14.1.—PICTURE-TUBE DATA

Type	Size (in.)	Gun	Heater V.	Heater A.	Base	Notes
Brimar						
C9A	9	Triode	2·0	1·4	MO(5)	
C9B	9	Triode	2·0	2·5	K(4)	Al.
C12A	12	Triode	2·0	1·4	MO(5)	
C12B	12	Triode	2·0	2·5	K(4)	Al.
C12D	12	Triode	2·0	2·5	K(4)	Al.
C12E	12	Triode	6·3	0·6	K(4)	Obsolete
C12FM	12	Tetrode	6·3	0·3	B12A(2)	I.T., E.C.
C14BM	14	Triode	6·3	0·6	B12A(1)	E.C., Al.
C14FM	14	Tetrode	12·3	0·3	B12A(2)	I.T., E.C., Al. (70°)
C14GM	14	Hexode	12·6	0·3	B12A(9)	E.S., I.T., E.C., Al. (70°)
C14JM	14	Hexode	6·3	0·6	B12A(9)	E.S., I.T., E.C., Al. (70°)
C14LM	14	Hexode	6·3	0·3	B12A(9)	E.S., E.C., Al. (70°)
C14PM	14	Hexode	6·3	0·3	B12A(9)	E.S., I.T., E.C., Al. (70°)
C15B	15	Triode	2·0	2·5	K(4)	Al.
C17AA	17	Hexode	6·3	0·3	B8H(11)	E.S., Al., E.C. (110°)
C17BM	17	Triode	6·3	0·6	B12A(1)	E.C., Al. (70°)
C17FM	17	Tetrode	12·6	0·3	B12A(2)	I.T., E.C., Al. (70°)
C17GM	17	Hexode	12·6	0·3	B12A(9)	E.S., I.T., E.C., Al. (70°)
C17HM	17	Tetrode	6·3	0·6	B12A(2)	I.T., E.C., Al.
C17JM	17	Hexode	6·3	0·6	B12A(9)	E.S., I.T., E.C., Al. (70°)
C17LM	17	Hexode	6·3	0·3	B12A(9)	E.C., Al. (70°)
C17PM	17	Hexode	6·3	0·3	B12A(9)	E.S., E.C., I.T., Al. (70°)
C17SM	17	Hexode	6·3	0·3	B12A(9)	E.S., E.C., Al. (90°)
C21AA	21	Hexode	6·3	0·3	B8H(11)	E.S., Al., E.C. (110°)
C21HM	21	Tetrode	6·3	0·6	B12A(2)	I.T., E.C., Al. (70°)
C21KM	21	Pentode	6·3	0·3	B12A(3)	I.T., E.C., Al.
C21NM	21	Pentode	6·3	0·3	B12A(3)	I.T., E.C., Al.
C21SM	21	Hexode	6·3	0·3	B12A(9)	E.S., E.C., Al. (90°)
C21TM	21	Tetrode	12·6	0·3	B12A(2)	I.T., E.C., Al. (90°)
C24KM	24	Pentode	6·3	0·3	B12A(3)	E.C., Al. (90°)
Cathodeon *						
C12/1	12	Tetrode	6·3	0·3	B12A(2)	I.T., E.C.
C14/3	14	Hexode	6·3	0·3	B12A(9)	E.S., I.T., E.C.
C14/3A	14	Hexode	6·3	0·3	B12A(9)	E.S., I.T., E.C., Al. (70°)
C17/1	17	Tetrode	6·3	0·3	B12A(2)	I.T., E.C. (70°)
C17/1A	17	Tetrode	6·3	0·3	B12A(2)	I.T., E.C., Al. (70°)
C17/4A	17	Tetrode	6·3	0·3	B12A(2)	I.T., E.C., Al. (90°)
C17/5A	17	Hexode	6·3	0·3	B12A(9)	I.T., E.C., E.S., Al. (90°)
C17/6A	17	Hexode	6·3	0·6	B8H(11)	E.S., E.C., Al. (110°)
C17/7A	17	Hexode	6·3	0·3	B8H(11)	E.S., E.C., Al. (110°)
C21/1A	21	Tetrode	6·3	0·3	B12A(2)	I.T., E.C., Al.
C36/24	14	Tetrode	6·3	0·3	B12A(2)	I.T., E.C. (70°)
Cossor						
AW43-80	17	Heptode	6·3	0·3	B12A(9)	E.S., I.T., Al., E.C. (90°)
AW43-88	17	Hexode	6·3	0·3	B8H(11)	E.S., Al., E.C. (110°)
CRM141	14	Tetrode	12·6	0·3	B12A(2)	I.T., Al. (67°)
CRM142	14	Tetrode	12·6	0·3	B12A(2)	I.T., Al. (67°)
CRM171	17	Tetrode	12·6	0·3	B12A(2)	I.T., Al. (69°)
CRM172	17	Tetrode	12·6	0·3	B12A(2)	I.T., Al., E.C. (69°)
MW31-74	12	Tetrode	6·3	0·3	B12A(2)	I.T., E.C. (63°)
MW36-44	14	Pentode	6·3	0·3	B12A(3)	I.T., E.C. (70°)
MW43-69	17	Pentode	6·3	0·3	B12A(3)	I.T., Al., E.C. (70°)

* For Cathodeon "Popular" tubes, the prefix "X" is used in place of "C" otherwise details are identical for both series.

Type	Size (in.)	Gun	Heater V.	Heater A.	Base	Notes
Cossor (contd.)						
MW53-80	21	Pentode	6·3	0·3	B12A(3)	I.T., Al., E.C. (90°)
65K/2	15	Triode	4	1·1	4-clip (7)	I.T. (45°)
75K	10	Triode	6·3	0·55	4-clip (7)	I.T. (52°)
85K	15	Triode	6·3	0·55	4-clip (7)	I.T. (52°)
108K	10	Triode	6·3	0·55	4-clip (7)	I.T. (50°)
112K	12	Tetrode	6·3	0·3	B12A(2)	Obsolete
121K	12	Tetrode	6·3	0·3	B12A(2)	Obsol. I.T., E.C. (60°)
141K	14	Tetrode	6·3	0·3	B12A(2)	Obsol. I.T., E.C. (70°)
171K	17	Tetrode	6·3	0·3	B12A(2)	Obsol. I.T., E.C. (70°)
172K	17	Pentode	6·3	0·3	B12A(3)	Obsol. I.T., E.C. (70°)
173K	17	Pentode	6·3	0·3	B12A(3)	Obsol. I.T., E.C., Al. (70°)
212K	21	Pentode	6·3	0·3	B12A(3)	I.T., E.C., Al. (90°)
Ediswan Mazda						
CME141	14	Hexode	12·6	0·3	B12A(9)	E.S., E.C., Al., I.T. (70°)
CME1402	14	Hexode	12·6	0·3	B12A(9)	E.S., E.C., Al., I.T. (90°)
CME1702	17	Hexode	12·6	0·3	B12A(9)	E.S., E.C., Al. (90°)
CME1703	17	Hexode	12·6	0·3	B8H(11)	E.S., Al., E.C. (110°)
CME1705	17	Pentode	12·6	0·3	B8H	E.S., Al., E.C. (110°)
CME2101	21	Hexode	12·6	0·3	B8H(11)	E.S., Al., E.C. (110°
CRM91	9	Triode	2·0	1·4	MO(5)	(64°)
CRM92	9	Triode	2·0	1·4	MO(5)	(57°)
CRM92A	9	Triode	2·0	1·4	MO(5)	(57°)
CRM93	9	Tetrode	12·6	0·3	B12A(2)	I.T., Al.
CRM121	12	Triode	2·0	1·4	MO(5)	(57°)
CRM121A	12	Triode	2·0	1·4	MO(5)	(57°)
CRM121B	12	Triode	2·0	1·4	MO(5)	(57°)
CRM122	12	Triode	7·3	0·3	MO(5)	(57°)
CRM123	12	Triode	2·0	1·4	MO(5)	Al. (57°)
CRM124	12	Tetrode	12·6	0·3	B12A(2)	I.T., E.C., Al. (57°)
CRM141	14	Tetrode	12·6	0·3	B12A(2)	I.T., Al. (67°)
CRM142	14	Tetrode	12·6	0·3	B12A(2)	I.T., Al. (67°)
CRM143	14	Tetrode	12·6	0·3	B12A(2)	I.T., Al. (70°)
CRM144	14	Tetrode	12·6	0·3	B12A(2)	I.T., E.C., Al. (70°)
CRM151	15	Triode	2·0	1·4	MO(5)	Al. (51°)
CRM152A	15	Triode	2·0	1·4	B12A(1)	Al. (67°)
CRM152B	15	Triode	2·0	1·4	B12A(1)	Al. (67°)
CRM153	15	Tetrode	12·6	0·3	B12A(2)	I.T., Al. (67°)
CRM171	17	Tetrode	12·6	0·3	B12A(2)	I.T., Al. (69°)
CRM172	17	Tetrode	12·6	0·3	B12A(2)	I.T., E.C., Al. (69°)
CRM173	17	Tetrode	12·6	0·3	B12A(2)	I.T., E.C., Al. (90°)
CRM211	21	Tetrode	12·6	0·3	B12A(2)	I.T., E.C., Al. (70°)
CRM212	21	Tetrode	12·6	0·3	B12A(2)	I.T., E.C., Al. (90°)
CRM241	24	Tetrode	12·6	0·3	B12A(2)	I.T., E.C., Al. (90°)
MW53-20	21	Pentode	6·3	0·3	B12A(3)	I.T., E.C., Al. (70°
Emiscope						
3/1	5	Triode	4·0	1·3	Side-wire	Obsolete
3/2	7	Triode	4·0	1·3	Side-wire	Obsolete
3/3	9	Triode	4·0	1·3	Side-wire	Obsolete
3/4	10	Triode	4·0	1·3	Side-wire	Obsolete
3/5	14	Triode	4·0	1·3	Side-wire	Obsolete
3/6A	15	Triode	4·0	1·3	Side-wire	Obsolete
3/16	10	Triode	13·3*	0·3	7-pin (2)	Al.
3/18	12	Triode	13·3*	0·3	7-pin (2)	Al.
3/20	10	Triode	11·5	0·3	4-clip (7)	Obsolete, I.T.

* Has been progressively reduced to 8·6 volts at 0·3 amp.

Type	Size (in.)	Gun	Heater V.	Heater A.	Base	Notes
Emiscope (contd.)						
3/31	12	Triode	13·0*	0·3	7-pin (2)	Al.
3/32	15	Triode	13·0*	0·3	7-pin (2)	Al.
4/13	21	Tetrode	13·0*	0·3	7-pin (3)	Obsolete, Al.
4/14T	14	Tetrode	13·0*	0·3	7-pin (3)	Al.
4/14TG	14	Tetrode	13·0*	0·3	7-pin (1)	Al., E.C.
4/15T	17	Tetrode	13·0*	0·3	7-pin (3)	Al.
4/15TG	17	Tetrode	13·0*	0·3	7-pin (1)	Al., E.C.
5/2	14	Pentode	8·5	0·3	7-pin (3)	E.S., Al., E.C.
5/2T	14	Pentode	8·5	0·3	7-pin (3)	E.S., Al., E.C.
5/3	17	Pentode	8·5	0·3	7-pin (3)	E.S., Al., E.C.
5/3T	17	Pentode	8·5	0·3	7-pin (3)	E.S., Al., E.C.
6/5	9	Hexode	4·0	1·3	7-pin split	E.S.
6/6	12	Hexode	4·0	1·3	7-pin split	E.S.
SE14/70	14	Hexode	6·3	0·3	B12A	I.T., Al., E.C.
SE17/70	17	Hexode	6·3	0·3	B12A	I.T., Al., E.C.
TA10	10	Tetrode	4·0	1·0	7-pin (1)	Al.
TA15	15	Tetrode	4·0	1·0	7-pin (1)	Al.
Emitron						
12XP4	12	Tetrode	6·3	0·3	B12A(2)	Obsol. I.T., E.C. (60°)
12XP4A	12	Tetrode	6·3	0·3	B12A(2)	I.T., E.C.
14KP4	14	Tetrode	6·3	0·3	B12A(2)	Obsol. I.T., E.C.
14KP4A	14	Tetrode	6·3	0·3	B12A(2)	Obsol. I.T., E.C. (70°)
14LP4	14	Tetrode	6·3	0·3	B12A(2)	I.T., E.C. (70°)
15EP4	15	Tetrode	6·3	0·3	B12A(2)	I.T., E.C. (52°)
17ASP4	17	Tetrode	6·3	0·3	B12A(2)	Obsol. I.T., E.C.
17AXP4	17	Tetrode	6·3	0·3	B12A(2)	I.T., E.C. (70°)
85K	15	Triode	6·3	0·55	4-clip (7)	Obsol. I.T. (52°)
108K	10	Triode	6·3	0·55	4-clip (7)	Obsol. I.T. (50°)
English Electric						
T901	16	Tetrode	6·3	0·6	B12A(2)	I.T., Metal cone
T901A	16	Tetrode	6·3	0·3	B12A(2)	I.T., Metal cone (70°)
T905	14	Tetrode	—	—	B12A(2)	Obsolete, I.T., E.C.
T906	14	Tetrode	6·3	0·3	B12A(2)	Obsolete, I.T., E.C., Al.
T908	17	Tetrode	6·3	0·3	B12A(2)	I.T., E.C.
T909	21	Tetrode	6·3	0·3	B12A(2)	I.T., Metal cone
T909A	21	—	6·3	0·3	B12A	I.T., Metal cone
T911	17	Tetrode	6·3	0·3	B12A(2)	I.T., E.C., Al.
T914A	17	—	6·3	0·3	B12A	I.T., Al.
T915	21	—	6·3	0·3	B12A	I.T., Al., Metal cone
Ferranti						
T9/2	9	Triode	4·0	1·0	K(4)	Obsolete
T9/3	9	Triode	4·0	1·0	K(4)	Obsolete
T9/5	9	Triode	4·0	1·0	K(4)	E.C.
T12/2	12	Triode	4·0	1·0	K(4)	Obsolete
T12/44	12	Triode	4·0	0·95	K(4)	
T12/46	12	Triode	6·3	0·6	K(4)	Obsolete
T12/54	12	Triode	4·0	0·95	K(4)	Obsolete, E.C.
T12/56	12	Triode	6·3	0·6	K(4)	Obsolete, E.C.
T12/71U	12	Triode	8·0	0·3	K(4)	Obsolete, E.C.
T12/72U	12	Triode	8·0	0·3	K(4)	E.C.
T12/81U	12	Triode	8·0	0·3	K(4)	Obsolete, Al.
T12/82U	12	Triode	8·0	0·3	K(4)	Obsolete, E.C., Al.
T12/91	12	Triode	2·0	1·5	K(4)	Obsolete

* Has been progressively reduced to 8·6 volts at 0·3 amp.

Type	Size (in.)	Gun	Heater V.	Heater A.	Base	Notes
Ferranti (contd.)						
T12/92	12	Triode	2·0	1·5	K(4)	E.C.
T12/100	12	Tetrode	6·3	0·3	B12A(2)	I.T., E.C.
T12/404	12	Triode	4·0	0·95	K(4)	Obsolete, Al.
T12/449	12	Triode	4·0	0·95	K(4)	Obsolete
T12/504	12	Triode	4·0	0·95	K(4)	Obsolete, Al., E.C.
T12/549	12	Triode	4·0	0·95	K(4)	E.C.
TR14/1	14	Triode	4·0	0·95	K(4)	Obsolete, Al.
TR14/2	14	Triode	4·0	0·95	K(4)	Obsolete, E.C., Al.
TR14/4	14	Triode	6·3	0·3	K(4)	Obsolete, E.C., Al.
TR14/8	14	Triode	6·3	0·3	B12A(1)	E.C., Al.
TR14/12	14	Tetrode	6·3	0·3	B12A(2)	Obsolete, Al.
TR14/13	14	Tetrode	6·3	0·3	B12A(2)	Obsolete, E.C., Al.
TR14/15	14	Tetrode	6·3	0·3	B12A(2)	Obsolete, E.C., Al.
TR14/21	14	Tetrode	6·3	0·3	B12A(2)	I.T., E.C.
TR14/22	14	Tetrode	6·3	0·3	B12A(2)	I.T., E.C., Al.
TR17/1	17	Triode	4·0	0·95	K(4)	Obsolete, Al.
TR17/2	17	Triode	4·0	0·95	K(4)	Obsolete, E.C., Al.
TR17/7	17	Tetrode	6·3	0·3	B12A(2)	Obsolete, Al.
TR17/8	17	Tetrode	6·3	0·3	B12A(2)	Obsolete, E.C., Al.
TR17/10	17	Tetrode	6·3	0·3	B12A(2)	Obsolete, E.C., Al.
TR17/21	17	Tetrode	6·3	0·3	B12A(2)	Obsolete, I.T., E.C.
TR17/22	17	Tetrode	6·3	0·3	B12A(2)	I.T., E.C., Al.
TR21/21	21	Tetrode	6·3	0·3	B12A(2)	Obsolete, I.T., E.C.
TR21/22	21	Tetrode	6·3	0·3	B12A(2)	Obsolete, I.T., E.C., Al.
MW31–74	12	Tetrode	6·3	0·3	B12A(2)	I.T., E.C.
MW36–24	14	Tetrode	6·3	0·3	B12A(2)	I.T., E.C.
MW36–44	14	Pentode	6·3	0·3	B12A(3)	I.T., E.C.
MW43–64	17	Pentode	6·3	0·3	B12A(3)	Obsolete, I.T., E.C.
MW43–69	17	Pentode	6·3	0·3	B12A(3)	I.T., Al., E.C.
MW53–80	21	Pentode	6·3	0·3	B12A(3)	I.T., Al., E.C. (90°)
G.E.C.						
6502	9	Triode	6·3	0·3	K(4)	Obsolete
6503	9	Triode	10·5	0·3	K(4)	Obsolete
6504	9	Triode	6·3	0·5	K(4)	Obsolete
6504A	9	Triode	6·3	0·5	K(4)	E.C., Al.
6505	9	Triode	10·5	0·3	K(4)	Obsolete, E.C.
6505A	9	Triode	10·5	0·3	K(4)	E.C., Al.
6506A	9	Triode	6·3	0·3	K(4)	Al.
6703A	12	Triode	6·3	0·5	K(4)	Obsolete, E.C., Al.
6704A	12	Triode	10·5	0·3	K(4)	Obsolete, E.C., Al.
6705A	12	Triode	6·3	0·5	K(4)	Obsolete, E.C., Al.
6706A	12	Triode	10·5	0·3	K(4)	Obsolete, E.C., Al.
6801A	14	Triode	6·3	0·5	K(4)	Al.
6802A	14	Triode	6·3	0·3	K(4)	Al.
6901A	16	Triode	6·3	0·3	B12A(1)	Al. (70°)
7101A	12	Triode	6·3	0·3	K(4)	E.C., Al.
7102A	12	Triode	6·3	0·3	K(4)	E.C., Al.
7201A	14	Triode	6·3	0·3	B12A(1)	E.C., Al.
7203A	14	Triode	6·3	0·3	B12A(1)	E.C., Al.
7204A	14	Tetrode	12·6	0·3	B12A(2)	E.C., Al.
7205A	14	Hexode	12·6	0·3	B12A(9)	E.S., I.T., E.C., Al.
7401A	17	Triode	6·3	0·3	B12A(1)	E.C., Al.
7404A	17	Tetrode	12·6	0·3	B12A(2)	E.C., Al.
7405A	17	Hexode	12·6	0·3	B8H(11)	E.S., Al., E.C. (110°)
7406A	17	Pentode	12·6	0·3	B8H	E.S., Al., E.C. (110°)
7501A	21	Triode	6·3	0·3	B12A(1)	E.C., Al.

Type	*Size (in.)*	*Gun*	*Heater*		*Base*	*Notes*
			V.	*A.*		
G.E.C. (contd.)						
7502A	21	Tetrode	12·6	0·3	B12A(2)	E.C., Al.
7503A	21	Hexode	12·6	0·3	BSH(11)	E.S., Al., E.C. (110°)
Mullard						
MW6-2	2½	Triode	6·3	0·3	S.C.(8)	Projection tube, E.C., Al.
MW22-7	9	Tetrode	6·3	0·6	BSG(6)	Obsolete
MW22-14	9	Tetrode	6·3	0·3	BSG(6)	Obsolete
MW22-14C	9	Tetrode	6·3	0·3	BSG(6)	Obsolete
MW22-16	9	Tetrode	6·3	0·3	B12A(2)	I.T., E.C. (60°)
MW22-17	9	Tetrode	6·3	0·3	B12A(2)	Obsolete
MW22-18	9	Tetrode	6·3	0·3	B12A(2)	Obsolete, E.C.
MW31-7	12	Tetrode	6·3	0·6	BSG(6)	Obsolete
MW31-14	12	Tetrode	6·3	0·3	BSG(6)	Obsolete, E.C.
MW31-14C	12	Tetrode	6·3	0·3	BSG(6)	Obsolete
MW31-16	12	Tetrode	6·3	0·3	B12A(2)	Obsolete, I.T., E.C.
MW31-17	12	Tetrode	6·3	0·3	B12A(2)	Obsolete
MW31-18	12	Tetrode	6·3	0·3	B12A(2)	Obsolete, E.C.
MW31-20	12	Tetrode	6·3	0·3	BSG(6)	Obsolete
MW31-21	12	Tetrode	6·3	0·3	BSG(6)	Obsolete, E.C.
MW31-22	12	Tetrode	6·3	0·3	B12A(2)	Obsolete
MW31-23	12	Tetrode	6·3	0·3	B12A(2)	Obsolete, E.C.
MW31-74	12	Tetrode	6·3	0·3	B12A(2)	I.T., E.C. (60°)
MW36-22	14	Tetrode	6·3	0·3	B12A(2)	Obsolete, I.T., E.C.
MW36-24	14	Tetrode	6·3	0·3	B12A(2)	I.T., E.C. (70°)
MW36-44	14	Pentode	6·3	0·3	B12A(3)	I.T., E.C. (70°)
MW41-1	16	Tetrode	6·3	0·3	B12A(2)	I.T., Met. (70°)
MW43-43	17	Pentode	6·3	0·3	B12A(3)	I.T., Met. (70°)
MW43-64	17	Pentode	6·3	0·3	B12A(3)	I.T., E.C. (70°)
MW43-69	17	Pentode	6·3	0·3	B12A(3)	I.T., Al., E.C. (70°)
MW43-80	17	Pentode	6·3	0·3	B12A(3)	I.T., Al., E.C. (90°)
MW53-20	21	Pentode	6·3	0·3	B12A(3)	I.T., Al., E.C. (70°)
MW53-80	21	Pentode	6·3	0·3	B12A(3)	I.T., Al., E.C. (90°)
AW36-20	14	Heptode	6·3	0·3	B12A(9)	I.T., E.C., E.S., Al. (70°)
AW36-21	14	Heptode	6·3	0·3	B12A(9)	E.S., I.T., E.C. (70°)
AW36-80	14	Heptode	6·3	0·3	B12A(9)	I.T., E.C., E.S., Al. (90°)
AW43-80	17	Heptode	6·3	0·3	B12A(9)	E.S., I.T., E.C. (90°)
AW43-88	17	Hexode	6·3	0·3	BSH(11)	E.S., Al., E.C. (110°)
AW53-80	21	Heptode	6·3	0·3	B12A(9)	E.S., I.T., E.C. (90°)
AW53-88	21	Hexode	6·3	0·3	BSH(11)	E.S., Al., E.C. (110°)
Pinnacle						
P12	12	Tetrode	6·3	0·3	B12A(2)	I.T., E.C.
P14	14	Triode	6·3	0·3	B12A(1)	I.T., E.C. (Obsolete)
P14ES	14	Heptode	6·3	0·3	B12A(9)	E.S., I.T., E.C. (70°)
P17	17	Tetrode	6·3	0·3	B12A(2)	I.T., E.C.
P17A	17	—	6·3	0·3	B12A(2)or(3)	I.T., Al., E.C.
P17AM	17	Tetrode	12·6	0·3	B12A(2)	I.T., Al., E.C. (69°)
P17EH	17	Hexode	6·3	0·3	BSH(11)	E.S., Al., E.C. (110°)
P17EN	17	Heptode	6·3	0·3	B12A(9)	E.S., I.T., E.C. (90°)
P17M	17	Tetrode	6·3	0·3	B12A(2)	I.T., E.C. (70°)
P17MN	17	Pentode	6·3	0·3	B12A(3)	I.T., Al., E.C. (90°)
P141	14	Tetrode	6·3	0·3	B12A(2)	I.T., E.C.

Notes.—E.S. = electrostatic focusing; E.C. = external conductive coating; I.T. = ion trap fitted; Al. = aluminised screen; Met = metal cone. Degrees in brackets are deflection angles. Numbers in brackets after base type refer to diagrams on pages 226 and 227.

Table 14.2.—Cathode-ray-tube Equivalents

Type	*Equivalents* *	*Type*	*Equivalents* *
AW36-21	P14ES	MW43-69	C17-2, 172K, 173K, P17A, TR17/22
AW43-80	P17EN, 17BTP4, 174K, C17/5A	MW53-80	C21KM, C21/1A, 212K, TR21/22
AW43-88	C17AA, P17EH, C17/7A	MW53-88	C21KM
AW53-80	21CLP4	P12	MW31-16, MW31-74, T12/100, C12FM, 12XP4A, 121K
AW53-88	C21AA	P14	C14BM, TR14/13, 7201A
C9A	CRM92, CRM92A	P14ES	AW36-21
C12A	CRM121, CRM121A, CRM121B	P17	MW43-64, TR17/21, 17ASP4, 172K
C12B	12MW3A	P17A	MW43-69, C17-1A, 172K, 173K
C12D	12MW3	P17AM	CRM172, 7404A
C12FM	121K, 12XP4, MW31-16, MW31-74, P12, T12/100, C12/1	P17EH	AW43-88, C17AA
C14/3A	C14PM, SE14/70	P17EN	AW43-80, 174K
C14PM	C14/3A, SE14/70	P17MN	MW43-80
C15B	15MW3A	P141	141K, 14KP4, 14KP4A
C17-1A	MW43-69, TR17/22	SE14/70	C14PM, C14/3A
C17-2	MW43-69	SE17/70	C17PM
C17AA	AW43-88	T12/2	C12D
C21AA	AW53-88	T12/100	MW31-74
C21KM	MW53-80	T901, A	MW41-1
C21TM	MW36-24	12MW3	C12D, T12/46
CME1402	7205A	12MW3A	C12B
CME1703	7405A	12XP4	C12FM, MW31-16, MW31-74
CME1705	7406A	12XP4A	MW31-74, 121K, C12/1
CME2101	7503A	14KP4A	141K, MW36-24, C36-24
CRM71	MW18-2	15MW3A	C15B
CRM91	MW22-3, C9A	17ASP4	171K, C17/1
CRM92, A	MW22-3, C9A	17AXP4	171K (near)
CRM121, A, B	C12A, CRM121	112K	MW31-18, C12FM, 12XP4
CRM144	7204A	121K	MW31-74, etc.
CRM172	7404A	141K	MW36-24, P141, 14KP4A, C36-24
CRM212	7502A	171K	17ASP4, C17/1
MW6-2	3NP4	172K	MW43-64, MW43-69, C17-2, P17A
MW18-2	CRM71	173K	MW43-69, C17-2, P17A
MW22-3	CRM92	212K	MW53-80, C21/1A
MW31-16	C12FM, 121K, 12XP4, MW31-74, C12/1	7204A	CRM144
MW31-18	112K	7205A	CME1402
MW31-74	C12FM, 121K, 12XP4A, C12/1	7404A	CRM172
MW36-24	141K, 14KP4A, 14LP4, C36-24	7405A	CME1703
MW41-1	T901, T901A	7406A	CME1705
MW43-64	172K, MW43-69, C17/1, TR17/21	7502A	CRM212
		7503A	CME2101

* *Note:* Not all types shown are direct equivalents but should prove satisfactory replacements.

TABLE 14.3.—PICTURE-TUBE REPLACEMENT TABLE

Original Tube	*Replacement*	*Modifications*
Cossor		
65K	65K/2	Fit ion trap
112K	MW31–74	Fit ion trap
121K	MW31–74	—
141K	MW36–44	Ensure that any connections to pin 7 are removed and anchored elsewhere. Then connect pin 7 to pin 11
171K	MW43–69	See note on 141K
172K	MW43–69	—
173K	MW43–69	—
Emiscope		
3/3	TA10	Modification kit AE351
3/4	TA10/J	Modification kit AE321
3/5	TA15/J	Modification kit AE313
3/6A	TA15/J	Modification kit AE313
3/20	3/16	Modification kit AE312
5/2T	SE14/70	Modification kit AE386
5/3T	SE17/70	Modification kit AE386
Ferranti		
T9/2	T9/3	—
T12/2	T12/44	Change mask T12/44 has a flat face
T12/46	T12/44	Insert 2·5-ohm, 2·5-w. resistor in series with one heater lead
T12/54	T12/549	—
T12/56	T12/549	Insert 2·5-ohm, 2·5-w. resistor in series with one heater lead
T12/71U	T12/72U	Earth external conductive coating
T12/81U	T12/72U	Earth external conductive coating
T12/82U	T12/72U	—
T12/404	T12/44	—
T12/449	T12/44	—
T12/504	T12/549	—
TR14/2	TR14/8	Refer to manufacturers for modification data
TR14/4	TR14/8	Change valveholder to duodecal type
TR14/15	TR14/13	—
TR17/2	TR17/21	Refer to manufacturers for modification data
TR17/8	TR17/10	—
G.E.C.		
6703A	7101A	
6704A	7101A	
6705A	7102A	Note differences in heater ratings
6706A	7102A	
Mazda		
CRM91	CRM91, 92, 92A	Physical dimensions of CRM92 and CRM92B differ from CRM91
CRM92	CRM92, 92A	—
CRM121	CRM121, 121A, 121B	—
CRM121A	CRM121A, 121B	—
CRM121B	CRM121B, CRM123	CRM123 provided that the E.H.T. exceeds 7·5 kV.
CRM152A	CRM152A, 152B	CRM152B has a grey face

Original Tube	*Replacement*	*Modifications*	
Mullard			
MW22–7	MW22–16	Change base, earth external coating	
MW22–14	MW22–16	Change base	
MW22–14C	MW22–16	Change base, earth external coating	
MW22–17	MW22–16	Earth external coating	Fit ion-trap magnet type IT6 *
MW22–18	MW22–16	—	
MW31–7	MW31–74	Change base, earth external coating	
MW31–14	MW31–74	Change base	
MW31–14C	MW31–74	Change base, earth external coating	
MW31–16	MW31–74	—	
MW31–17	MW31–74	Earth external coating	
MW31–18	MW31–74		
MW31–20	MW31–74	Change base, earth external coating	Fit ion-trap magnet type IT6 *
MW31–21	MW31–74	Change base	
MW31–22	MW31–74	Change base, earth external coating	
MW31–23	MW31–74	Change base	
MW36–22	MW36–44	Connect pin 7 (a2) to pin 11 (k)	
MW43–64	MW43–69	—	
Cathodeon			
C17/2	C17/1 or X17/1	—	
C17/6A	C17/7A or X17/7A	Remove 0·6 amp. heater transformer, insert tube heater in series heater chain.	

* This may necessitate modifying the rear tube support, and in some receivers this modification cannot be made. In such cases further instructions regarding replacements can be obtained from Technical Service Dept., Mullard Ltd.

The connections to the socket should also be flexible. Provision should be made for the rotation of the tube.

There should be adequate ventilation to ensure a safe temperature under all conditions, and it should be appreciated that the heat generated in adjacent components may largely determine the final temperature of the tube.

The potential difference between the heater and cathode should not exceed 50 V, except where this is specified by the manufacturer.

There must always be a D.C. connection between each electrode and the cathode. The resistance of this connection should be the minimum practicable.

Care should be taken to avoid scratching or otherwise damaging the surface of the glass.

To ensure maximum cathode life, tubes should be run at the minimum useful brightness.

To prevent damage to the screen material, tubes should not be operated with a stationary or slowly moving spot, except at low beam current density.

Stray magnetic fields may produce serious, adverse effects. Interference from such fields may be minimised by the suitable spacing and orientation of neighbouring components.

[SECTION 15]

VALVE DATA

This section gives heater ratings, valve-base connections and equivalents for the valves commonly fitted to modern television receivers.

Symbols Used to Indicate Pin Connections

The recommended electrode letter symbols of the British Standards Institution, listed in B.S. 1409 : 1947, have, wherever possible, been followed. Those used in the tables on the following pages are explained below :

a	anode
k	cathode
g	grid
h	heater
f	filament
M	external conductive coating
s	internal shield

In cases where a valve has more than one electrode system of the same type, electrodes of the same type are distinguished by the addition of " primes ". The example below is for a double diode with separate cathodes :

$$k' \quad a'' \quad h \quad h \quad k'' \quad s \quad a'$$

In the case of multiple valves using different electrode systems the respective electrodes are distinguished by the addition of the following subscripts :

d	diode
t	triode
p	pentode
h	hexode, heptode, etc.

For example, in the case of a double-diode triode with common cathode, the following symbols would be used :

$$g \quad k \quad h \quad h \quad a'_d \quad a''_d \quad a_t$$

Subscripts are omitted wherever confusion is not likely to arise, for example in the case of the grids in the pentode system of a triode pentode.

Valve Practice

The following are among the recommendations made by the British Valve Association for the correct use of valves :

Manufacturers' ratings should be carefully observed.

Heater or filament voltages should not vary by more than 7 per cent from rated values.

The potential difference between the cathode and heater should not normally exceed 150 V unless the valve has been specially designed for A.C./D.C. operation.

Ventilation should be adequate to ensure a safe bulb temperature at all times.

A limiting resistor should always be placed in series with a rectifying valve when used in conjunction with a condenser-input filter.

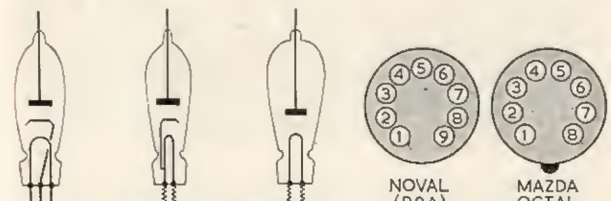
It is generally undesirable to use spare socket contacts as connecting tags.

There should always be a D.C. continuity between each electrode and cathode; and the resistance of this connection should be the least practicable.

The heat dissipated at the electrodes should be the minimum possible : common causes of excessive dissipation are incorrect tuning of associated circuits, unnecessarily high no-signal currents, or parasitic oscillations.

BRITISH 4 PIN (A Base) · BRITISH 5 PIN (O Base) · BRITISH 7 PIN (M Base) · SIDE CONTACT (P Base) · U.X. 4 PIN

7 PIN MINATURE (B7G) · 8 PIN MINATURE (B8A) · LOCTAL (B8G) · OCTAL (K Base) · 9 PIN ALL GLASS (B9G)



B3G · SPECIAL 1 · SPECIAL 2 · NOVAL (B9A) · MAZDA OCTAL (MO)

TABLE 15.1.—VALVE DATA

Type	Description	Heater Volts	Heater Amp.	Pin 1	Pin 2	Pin 3	Pin 4	Pin 5	Pin 6	Pin 7	Pin 8	Pin 9	Cap	Base
AZ31	Full-wave rectifier	4·0	1·1	—	f	—	a'	—	a''	—	f	—	—	K
B36	Double triode	12·6	0·3	g'	a'	k'	g''	a''	k''	h	h	—	—	K
B65	Double triode	6·3	0·6	g'	a'	k'	g''	a''	k''	h	h	—	—	K
B152	Double triode	12·6 c.t.	0·15	a''	g''	k''	h	h	a'	g'	k'	h_{tap}	—	B9A
B309	Double triode	12·6 c.t.	0·15	a''	g''	k''	h	h	a'	g'	k'	h_{tap}	—	B9A
B319	Double triode	7·0	0·3	k''	g'', s	a''	h	h	g'	k'_{in}	k'_{out}	a'	—	B9A
B329	Double triode	12·6 c.t.	0·15	a''	g''	k''	h	h	a'	g'	k'	h_{tap}	—	B9A
B339	Double triode	12·6 c.t.	0·15	a''	g''	k''	h	h	a'	g'	k'	h_{tap}	—	B9A
B719	Double triode	6·3	0·45	a''	g''	k''	h	h	a'	g'	k'	s	—	B9A
B729	Double triode	6·3	0·3	a''	g''	k''	h	h	a'	g'	k'	s	—	B9A
D1	Diode	4·0	0·2	h	k	h	—	—	—	—	—	—	a	B3G
D77	Double diode	6·3	0·3	k'	a''	h	h	k''	s	a'	—	—	—	B7G
D152	Double diode	6·3	0·3	k'	a''	h	h	k''	s	a'	—	—	—	B7G
DD41	Double diode	4·0	0·5	h	k'	a'	s	a''	M	k''	h	—	—	MO
DH77	Double diode triode	6·3	0·3	g	k	h	h	a'_d	a''_d	at	—	—	—	B7G
EA50	Diode	6·3	0·15	h	k	h	—	—	—	—	—	—	a	B3G
EABC80	Triple diode triode *	6·3	0·45	a'	a''	k''	h	h	a'''	k, s	g	at	—	B9A
EAF42	Diode vari-mu R.F. pentode	6·3	0·2	h	a_p	a_d	g_3	g_2	g_1	k, s	h	—	—	B8A
EB34	Double diode †	6·3	0·2	s	h	a'	k'	a''	—	h	k''	—	—	K
EB41	Double diode †	6·3	0·3	h	—	k'	a'	s	a''	k''	h	—	—	B8A
EB91	Double diode	6·3	0·3	k'	a''	h	h	k''	s	a'	—	—	—	B7G
EBC33	Double diode triode	6·3	0·2	s	h	at	a'_d	a''_d	—	h	k	—	g	K
EBC41	Double diode triode	6·3	0·23	h	at	g	s	a'_d	a''_d	k	h	—	—	B8A
EBC90	Double diode triode	6·3	0·3	g	k	h	h	a''_d	a'_d	a	—	—	—	B7G
EBF80	Double diode vari-mu R.F. pentode	6·3	0·3	g_2	g_1	k	h	h	ap	a'_d	a''_d	g_3	—	B9A
EBF89	Double diode vari-mu R.F. pentode	6·3	0·3	g_2	g_1	k, s	h	h	ap	a'_d	a''_d	g_3	—	B9A
ECC33	Double triode	6·3	0·4	g'	a'	k'	g''	a''	k''	h	h	—	—	K

* Separate cathode for one diode. † Separate cathodes.

Type	Description	Heater Volts	Heater Amp.	Pin 1	Pin 2	Pin 3	Pin 4	Pin 5	Pin 6	Pin 7	Pin 8	Pin 9	Cap	Base
ECC34	Double triode	6·3	0·95	g'	a'	k'	g''	a''	k''	h	h	—	—	K
ECC40	Double triode *	6·3	0·6	h	a'	g'	k'	a''	g''	k''	h	—	—	B8A
ECC81	Double triode	12·6 c.t.	0·15	a'	g'	k'	h	h	a''	g''	k''	h_{tap}	—	B9A
ECC82	Double triode	12·6 c.t.	0·15	a'	g'	k'	h	h	a''	g''	k''	h_{tap}	—	B9A
ECC83	Double triode †*	12·6 / 6·3	0·15 / 0·3	a''	g''	k''	h	h	a'	g'	k'	h_{tap}	—	B9A
ECC84	Double triode	6·3	0·34	k''	g'', s	a''	h	h	g'	k'_{in}	k'_{out}	a'	—	B9A
ECC85	Double triode *	6·3	0·435	a'	g'	k'	h	h	a''	g''	k''	s	—	B9A
ECC91	Double triode	6·3	0·45	a''	a'	h	h	g'	g''	k	—	—	—	B7G
ECF80	Triode pentode	6·3	0·43	a_t	g_1	g_2	h	h	a_p	k_p, g_3, s	k_t	g_t	—	B9A
ECF82	Triode pentode	6·3	0·45	a_t	g_1	g_2	h	h	a_p	k_p, g_3, s	k_t	g_t	—	B9A
ECH35	Triode hexode	6·3	0·225	s	h	a_h	$g_{2,4}$	$g_{t,3}$	a_t	h	k	—	g_1	K
ECH42	Triode hexode	6·3	0·23	h	a_h	a_t	$g_{t,3}$	$g_{2,4}$	g_1	k	h	—	—	B8A
ECL80	Triode output pentode	6·3	0·3	a_t	g_t	k	h	h	a_p	g_2	g_2	g_1	—	B9A
ECL82	Triode output pentode (sep. cathodes)	6·3	0·78	g_t	k_p, s	g_{1p}	h	h	a_p	g_{2p}	k_t	a_t	—	B9A
EF39	Vari-mu R.F. pentode	6·3	0·2	s	h	a	g_2	g_3	—	h	k	—	g_1	K
EF41	Vari-mu R.F. pentode	6·3	0·2	h	a	i.c.	i.c.	g_3	g_1	k, g_3	h	—	—	B8A
EF42	R.F. pentode	6·3	0·33	h	a	s	g_3	g_2	g_1	k	h	—	—	B8A
EF50	R.F. pentode	6·3	0·3	h	g_3	a	g_2	s	k	g_1	s	h	—	B9G
EF80	High slope R.F. pentode	6·3	0·3	k	g_1	k	h	h	s	a	g_2	g_3	—	B9A
EF85	Vari-mu R.F. pentode	6·3	0·3	k	g_1	k	h	h	s	a	g_2	g_3	—	B9A
EF89	R.F. pentode	6·3	0·2	s	g_1	k	h	h	s	a	g_2	g_3	—	B9A
EF183	Vari-mu frame-grid pentode	6·3	0·3	k	g_1	k	h	h	s	a	g_2	g_3	—	B9A
EF184	Frame-grid R.F. pentode	6·3	0·3	k	g_1	k	h	h	s	a	g_2	g_3	—	B9A
EF91	R.F. pentode	6·3	0·3	g_1	k	h	h	a	s, g_3	g_2	—	—	—	B7G
EL33	Output pentode	6·3	0·9	—	h	a	g_2	g_1	—	h	k, g_3	—	—	K
EL38	Output pentode	6·3	1·4	g_3	h	—	g_2	g_1	—	h	k	—	a	K
EL41	Output pentode	6·3	0·7	h	a	i.c.	i.c.	g_2	g_1	k, g_3	h	—	—	B8A
EL42	Output pentode	6·3	0·2	h	a	i.c.	i.c.	g_2	g_1	k, g_3	h	—	—	B8A
EL81	Output pentode	6·3	1·05	i.c.	g_1	k	h	h	i.c.	i.c.	g_2	g_3	a	B9A

* Separate cathodes. † Centre-tapped filament or heater.

Type	Description	Heater		Pin Connections										Base
		Volts	Amp.	1	2	3	4	5	6	7	8	9	Cap	
EL83	Output pentode	6·3	0·71	g_2	g_1	k	h	h	g_3	a	s	i.c.	—	B9A
EL84	Output pentode	6·3	0·76	i.c.	g_1	g_3, k	h	h	i.c.	a	i.c.	g_2	—	B9A
EL820	Line output pentode	6·3	1·0	i.c.	g_1	k	h	h	i.c.	i.c.	g_2	g_3	a	B9A
EL821	Video output pentode	6·3	0·75	i.c.	g_1	k	h	h	i.c.	a	g_3	g_2	—	B9A
EL822	Video output pentode	6·3	0·75	i.c.	g_1	k	h	h	i.c.	a	g_2	g_3	-	B9A
EY51	E.H.T. rectifier	6·3	0·09	Special Base										Spec. 1
EY83	Boost diode	6·3	1·0	—	—	—	h	h	—	—	—	a	k	B9A
EY86	E.H.T. rectifier	6·3	0·09	h, k, s	h	—†	h, k, s	h	h, k, s	—†	h	h, k, s	a	B9A
EY91	Half-wave rectifier	6·3	0·42	a	k	h	h	a	—	—	—	—	—	B7G
EZ35	Full-wave rectifier *	6·3	0·6	—	h	a'	—	a''	—	h	k	—	—	K
EZ80	Full-wave rectifier *	6·3	0·6	a'	i.c.	k	h	h	i.c.	a''	i.c.	i.c.	—	B9A
FW4–500	Full-wave rectifier	4·0	3·0	a'	a''	f	f	—	—	—	—	—	—	A
GZ30	Full-wave rectifier *	5·0	2·0	—	h	—	a'	—	a''	—	k, h	—	—	K
GZ32	Full-wave rectifier *	5·0	2·3	—	h	—	a'	—	a''	—	h, k	—	—	K
HL42DD	Double diode triode	4·0	0·65	h	k	a_t	—	a''	M	a'	h	—	g	MO
HN309	Triode pentode	12·6	0·3	a_t	g_t	k_t	h	h	a_p	k_p, g_3	g_2	g_1	—	B9A
HVR2	E.H.T. rectifier	4·0	0·65	—	—	k, h	h	—	—	—	—	—	a	A
KT33C	Output tetrode ‡	13 25	0·6 0·3	h.c.t.	h	a	g_2	g_1	—	h	k	—	—	K
KT36	Output tetrode	26·0	0·3	—	h	—	g_2	g_1	—	h	k	—	a	K
KT44	Output tetrode	4·0	2·0	—	g_1	—	h	h	k	g_2	—	—	a	M
KT61	Output tetrode	6·3	0·95	M	h	a	g_2	g_1	—	h	k	—	—	K
L63	Triode	6·3	0·3	s	h	a	—	g	—	h	k	—	—	K
LN119	Triode pentode (sep. cathodes)	50	0·1	g_t	k_p, g_3, s	g_1	h	h	a_p	g_2	k_t	a_t	—	B9A
LN152	Triode pentode	6·3	0·3	a_t	g_t	k	h	h	a_p	g_3	g_2	g_1	—	B9A
LN309	Triode output pentode	13·0	0·3	a_t	g_t	k_t	h	h	a_p	k_p, g_3	g_2	g_1	—	B9A
LZ319	Triode pentode	9·0	0·3	a_t	g_1	g_2	h	h	a_p	k_p, g_3	k_t	g_t	—	B9A
LZ329	Frequency changer	9·0	0·3	a_t	g_1	g_2	h	h	a_p	k_p, g_3	k_t	g_t	—	B9A
N37	Output pentode	13·0	0·3	g_1	k, g_3	h	h	a	i.c.	g_2	—	—	—	B7G
N78	Output pentode	6·3	0·64	g_1	k, g_3	h	h	a	i.c.	g_2	—	—	—	B7G
N145	Output pentode	40·0	0·1	h	a	i.c.	i.c.	g_2	g_1	k, g_3	h	—	—	B8A
N147	Output pentode	6·3	0·9	—	h	a	g_2	g_1	—	h	k, g_3	—	—	K

* Indirectly heated. † Pins 3 and 7 of EY86 must not be earthed. ‡ Centre-tapped filament or heater.

Type	Description	Heater		Pin Connections										Base
		Volts	Amp.	1	2	3	4	5	6	7	8	9	Cap	
N150	Output pentode	6·3	0·7	h	a	g_3, k	i.c.	g_2	g_1	k	h	—	—	B8A
N151	Output pentode	6·3	0·2	h	a	g_3, k	i.c.	g_2	g_1	k	h	—	—	B8A
N152	Output pentode	21·5	0·3	i.c.	g_1	k	h	h	i.c.	i.c.	g_2	g_3	a	B9A
N153	Output pentode	15·0	0·3	g_2	g_1	k	h	h	g_3	a	s	—	—	B9A
N308	Line output tetrode	25	0·3	—	h	i.c.	g_2	g_1	—	h	k	—	a	K
N309	Output pentode	15·0	0·3	g_2	g_1	k	h	h	g_3	a	s	—	—	B9A
N329	Output pentode	16·5	0·3	i.c.	g_1	k, g_3	h	h	i.c.	a	i.c.	g_2	—	B9A
N339	Output pentode	20·0	0·3	i.c.	g_1	k	h	h	i.c.	i.c.	g_2	g_3	a	B9A
N359	Line output pentode	21·5	0·3	i.c.	g_1	k	h	h	i.c.	i.c.	g_2	g_3	a	B9A
N369	Output pentode	12·6	0·3	i.c.	g_1	k	h	h	i.c.	a	i.c.	g_2	—	B9A
N379	Frame output pentode	15·0	0·3	i.c.	g_1	k, g_3	h	h	i.c.	a	i.c.	g_2	—	B9A
N709	Power pentode	6·3	0·76	i.c.	g_1	k, g_3	h	h	i.c.	a	i.c.	g_2	—	B9A
OM4	Double diode triode	6·3	0·2	s	h	a_t	a'	a''	—	h	k	—	g	K
OM6	R.F. pentode	6·3	0·2	s	h	a	g_2	g_3	—	h	k	—	g_1	K
OM10	Frequency changer	6·3	0·2	s	h	a_h	$g_{2,4}$	$g_{1,3}$	a_t	h	k	—	g_1	K
P41	Oscillator triode	4·0	0·95	h	k	a	—	g	M	—	h	—	—	MO
PABC80	Triple diode triode	9·5	0·3	a'''_d	a''_d	k''_d	h	h	a'_d	k, s	g	a	—	B9A
PCC84	Double triode	7·0	0·3	k''	g'', s	a''	h	h	g'	k'_{in}	k'_{out}	a'	—	B9A
PCC85	Double-triode	9·0	0·3	a''	g''	k''	h	h	a'	g'	k'	s	—	B9A
PCC88	Double triode (sep. cathodes)	7·0	0·3	a''	g''	k''	h	h	a'	g'	k'	s	—	B9A
PCC89	Double triode	7·2	0·3	k''	g'', s	a''	h	h	g'	k'	k'	a'	—	B9A
PCF80	Frequency changer	9·0	0·3	a_t	g_1	g_2	h	h	a_p	k_p, s, g_3	k_t	g_t	—	B9A
PCF82	Triode pentode	9·5	0·3	a_t	g_1	g_2	h	h	a_p	k_ps, g_3	k_t	g_t	—	B9A
PCF84	Triode pentode freq. changer	9·0	0·3	g_2	a_p	a_t	h	h	g_t	k, g_3, s	g_1	k, g_3, s	—	B9A
PCF86	Frame-grid triode pentode	8·0	0·3	k, g_3 s	g_1	k, g_3 s	h	h	g_t	a_t	a_p	g_2	—	B9A
PCL82	Triode output pentode	16·0	0·3	g_t	k_p, g_3 s	g_1	h	h	a_p	g_2	k_t	a_t	—	B9A
PCL83	Triode output pentode	12·6	0·3	a_t	g_t	k_t	h	h	a_p	k_p, g_3	g_2	g_1	—	B9A
PCL84	Video output pentode with triode	15·0	0·3	g_t	a_t	k_t	h	h	a_p	k_p, g_3, s	g_1	g_2	—	B9A

Type	Description	Heater Volts	Heater Amp.	Pin 1	Pin 2	Pin 3	Pin 4	Pin 5	Pin 6	Pin 7	Pin 8	Pin 9	Cap	Base
PEN45	Output tetrode	4·0	1·75	h	k	a	g_2	g_1	M	—	h	—	—	MO
PEN46	Output tetrode	4·0	1·75	h	k	—	g_2	g_1	—	—	h	—	a	MO
PL33	Output pentode	19·0	0·3	—	h	a	g_2	g_1	—	h	g_3, k	—	—	K
PL36	Output pentode	25·0	0·3	i.c.	h	i.c.	g_2	g_1	—	h	k, g_3	—	a	K
PL38	Output pentode	30·0	0·3	g_3	h	s	g_2	g_1	—	h	k	—	a	K
PL81	Output pentode	21·5	0·3	i.c.	g_1	k	h	h	i.c.	i.c.	g_3	g_3	a	B9A
PL82	Output pentode	16·5	0·3	—	g_1	k, g_3	h	h	—	a	—	g_2	—	B9A
PL83	Video pentode	15·0	0·3	g_3	g_1	k	h	h	g_2	a	s	—	—	B9A
PL84	Frame output pentode	15·0	0·3	i.c.	g_1	k, g_3	h	h	i.c.	a	i.c.	g_2	—	B9A
PL820	Output pentode	21·5	0·3	i.c.	g_1	k	h	h	i.c.	i.c.	g_3	g_2	a	B9A
PY31	Half-wave rectifier	17·0	0·3	—	h	—	—	a	—	h	k	—	—	K
PY32	Half-wave rectifier	29·0	0·3	—	h	a †	—	a †	i.c.	h	k	—	—	K
PY80	Boost diode	19·0	0·3	i.c.	i.c.	k	h	h	i.c.	i.c.	i.c.	a	—	B9A
PY81	Boost diode	17·0	0·3	i.c.	i.c.	i.c.	h	h	i.c.	i.c.	i.c.	a	k	B9A
PY82	Half-wave rectifier *	19·0	0·3	i.c.	i.c.	k	h	h	i.c.	i.c.	i.c.	a	—	B9A
PY83	Booster diode	20·0	0·3	i.c.	i.c.	i.c.	h	h	i.c.	i.c.	i.c.	a	k	B9A
PZ30	Full-wave rectifier	52·0 c.t.	0·3	—	h	a′	k′	a″	h_{tap}	h	k″	—	—	K
R12	E.H.T. rectifier	6·3	0·09	Special Base										Spec. 1
R16/1T2	E.H.T. rectifier	1·4	0·14	Special Base										Spec. 2
R19	Half-wave rectifier	1·25	0·2	s, h	h	i.c.	s, h	h	h	i.c.	h	h	a	B9A
SD6	Diode	6·3	0·15	s	a	h	h	k	s	s	—	—	—	B7G
SP6	R.F. pentode	6·3	0·3	g_1	k	h	h	a	s, g_3	g_2	—	—	—	B7G
SP41	R.F. pentode	4·0	0·95	h	k	a	g_2	g_3	M	—	h	—	g_1	MO
SP42	Video amplifier	4·0	0·95	h	k	a	g_2	g_3	M	—	h	—	g_1	MO
SU61	E.H.T. rectifier	6·3	0·08	Special Base										Spec. 1
SU2150	E.H.T. rectifier	2·0	1·15	—	—	h, k	h	—	—	—	—	—	a	A
T41	Gas triode	4·0	1·5	h	k	a	—	g	M	—	h	—	—	MO
TYS6F	E.H.T. rectifier	7·4	0·077	h, k, s	h	n.c.‡	h, k, s	h	h, k, s	n.c.‡	h	h, k, s	a	B9A
U22	E.H.T. rectifier	2·0	2·0	h, k, s	—	—	—	—	—	—	h	—	a	MO
U24	E.H.T. rectifier	2·0	0·15	—	h	—	—	—	—	h, k	s	—	a	K
U25	E.H.T. rectifier	2·0	0·2	Special Base										Spec.
U26	E.H.T. rectifier	2·0	0·35	s, h	h	i.c.	s, h	h	h	i.c.	h	h	a	B9A

* Indirectly heated. † Pins 3 and 5 of PY32 must be connected in circuit through appropriate limiting resistor.
‡ Pins 3 and 7 of TYS6F may be connected only to points in heater circuit and must not be earthed.

Type	Description	Heater Volts	Heater Amp.	Pin 1	Pin 2	Pin 3	Pin 4	Pin 5	Pin 6	Pin 7	Pin 8	Pin 9	Cap	Base
U31	Half-wave rectifier	26·0	0·3	—	h	—	—	a	—	h	k	—	—	K
U33	E.H.T. rectifier	2·0	1·0	—	—	f	f	—	—	—	—	—	a	A
U35	E.H.T. rectifier	1·4	0·12	i.c.	f	—	—	—	—	—	f	—	a	K
U37	E.H.T. rectifier	1·4	0·14	Special Base										Spec.
U43	E.H.T. rectifier	6·3	0·09	Special Base										Spec. 2
U45	Half-wave rectifier	6·3	0·12	Special Base										Spec. 1
U47	E.H.T. rectifier	2·0	0·2	Special Base										Spec. 1
U49	Half-wave rectifier	2·0	0·35	h, k, s	h	—	h, k, s	h	h, k, s	—	h	h, k, s	a	B9A
U52	Full-wave rectifier	5·0	3·0	—	h	—	a′	—	a″	—	h	—	—	K
U143	Full-wave rectifier	4·0	1·1	—	h	—	a′	—	a″	—	h	—	—	K
U145	Half-wave rectifier	40·0	0·1	h	a	—	i.c.	i.c.	i.c.	k	h	—	—	B8A
U147	Full-wave rectifier	6·3	0·6	—	h	a′	—	a″	—	h	k	—	—	K
U151	E.H.T. rectifier	6·3	0·09	Special Base										Spec. 1
U152	Boost diode	19·0	0·3	i.c.	i.c.	k	h	h	i.c.	i.c.	i.c.	a	—	B9A
U153	Booster diode	17·0	0·3	i.c.	i.c.	i.c.	h	h	i.c.	i.c.	i.c.	a	k	B9A
U154	Half-wave rectifier	19·0	0·3	i.c.	i.c.	k	h	h	i.c.	i.c.	i.c.	a	—	B9A
U191	Booster diode	19·0	0·3	—	i.c.	i.c.	—	a	—	h	h	—	k	K
U192	Half-wave rectifier (I.H.	19·0	0·3	i.c.	i.c.	k	h	h	i.c.	i.c.	i.c.	a	—	B9A
U251	Booster diode	25·0	0·3	i.c.	i.c.	i.c.	h	h	i.c.	i.c.	i.c.	a	k	B9A
U281	Half-wave rectifier	28·0	0·2	—	h	—	—	a	—	h	k	—	—	K
U282	Boost diode	28·0	0·2	—	—	k	—	—	—	h	h	—	a	K
U291	Half-wave rectifier (I.H.)	29·0	0·3	n.c.	h	a	—	a	i.c.	h	k	—	—	K
U309	Booster diode	20·0	0·3	i.c.	i.c.	k	h	h	i.c.	i.c.	i.c.	a	—	B9A
U319	Half-wave rectifier	20·0	0·3	i.c.	i.c.	k	h	h	i.c.	i.c.	i.c.	a	—	B9A
U329	Boost rectifier	25·0	0·3	i.c.	i.c.	i.c.	h	h	i.c.	i.c.	i.c.	a	k	B9A
U339	Efficiency diode	19	0·3	—	i.c.	i.c.	—	a	—	h	h	—	k	K
U403	Half-wave rectifier	40·0	0·2	h	—	k	—	a	M	—	h	—	—	MO
U404	Half-wave rectifier	40·0	0·1	h	a	—	i.c.	i.c.	i.c.	k	h	—	—	B8A
U801	Half-wave rectifier	80·0	0·2	k_{d_1}	h	a'_{d_1}	a''_{d_1}	a'_{d_2}	a''_{d_2}	h	k_{d_2}	—	—	K
UAF42	Diode vari-mu R.F. pentode	12·6	0·1	h	a_p	a_d	g_3	g_2	g_1	k, s	h	—	—	B8A
UB41	Double diode	19·0	0·1	h	—	k′	a′	s	a″	k″	h	—	—	B8A
UBC41	Double diode triode	14·0	0·1	h	a_t	g	s	a'_d	a''_d	k	h	—	—	B8A
UBF80	Double diode R.F. pentode	17·0	0·1	g_3	g_2	k	h	h	a_p	a′	a″	g_1	—	B9A
UCC84	Double triode	21·0	0·1	k″	g″, s	a″	h	h	g′	k'_{in}	k'_{out}	a′	—	B9A

Type	Description	Heater		Pin Connections										Base
		Volts	Amp.	1	2	3	4	5	6	7	8	9	Cap	
UCC85	V.H.F. double triode	26·0	0·1	a''	g''	k''	h	h	a'	g'	k'	s	—	B9A
UCF80	Triode pentode	27·0	0·1	at	g_1	g_2	h	h	ap	kp, g_3, s	kt	gt	—	B9A
UCH42	Triode hexode frequency changer	14·0	0·1	h	ah	at	gt, s	$g_{2,4}$	g_1	k	h	—	—	B8A
UF41	Vari-mu R.F. pentode	12·6	0·1	h	a	g_3, k	i.c.	g_2	g_1	k	h	—	—	B8A
UF42	High slope R.F. pentode	21·0	0·1	h	a	s	g_3	g_2	g_1	k	h	—	—	B8A
UL41	Output pentode	45·0	0·1	h	a	g_3, k	i.c.	g_2	g_1	k	h	—	—	B8A
UL44	Output pentode	45·0	0·1	h	—	—	g_3	g_2	g_1	k	h	—	a	B8A
UL46	Low microphony output pentode	45·0	0·1	h	a	g_3, k	i.c.	g_2	g_1	k	h	—	—	B8A
UU8	Full-wave rectifier	4·0	2·8	h, k	—	a'	—	a''	M	—	h	—	—	MO
UY41	Half-wave rectifier	31·0	0·1	h	a	—	i.c.	i.c.	i.c.	k	h	—	—	B8A
W719	R.F. pentode	6·3	0·3	k	g_1	k	h	h	s	a	g_2	g_3	—	B9A
W727	Vari-mu R.F. pentode	6·3	0·3	g_1	g_2, s	h	h	a	g_3	k	—	—	—	B7G
W729	R.F. pentode	6·3	0·3	k	g_1	k	h	h	s	a	g_2	g_3	—	B9A
WD142	Diode vari-mu R.F. pentode	12·6	0·1	h	ap	ad	g_3	g_2	g_1	k, s	h	—	—	B8A
WD709	Double diode R.F. pentode	6·3	0·3	g_2	g_1	k	h	h	ap	a'd	a''d	g_3	—	B9A
X78	Triode hexode frequency changer	6·3	0·3	$g_{2,4}$	g_1	k h	h	ah	at	gt, s	—	—	—	B7G
Z63	R.F. pentode	6·3	0·3	s	h	a	g_2	g_3	—	h	k	—	g_1	K
Z66	R.F. pentode	6·3	0·63	—	h	a	g_2	g_3, s	—	h	k	—	g_1	K
Z77	R.F. pentode	6·3	0·3	g_1	k	h	h	a	g_3, s	g_2	—	—	—	B7G
Z150	R.F. pentode	6·3	0·33	h	a	s	g_3	g_2	g_1	k	h	—	—	B8A
Z152	R.F. pentode	6·3	0·3	k	g_1	k	h	h	s	a	g_2	g_3	—	B9A
Z329	R.F. pentode	7·3	0·3	k	g_1	k	h	h	s	a	g_2	g_3	—	B9A
Z359	Video amplifier	12·6	0·3	k	g_1	k	h	h	—	a	g_2	g_3, s	—	B9A
Z719	R.F. pentode	6·3	0·3	k	g_1	k	h	h	s	a	g_2	g_3	—	B9A
Z759	Video amplifier	6·3	0·6	k	g_1	k	—	h	h	a	g_2	g_3, s	—	B9A
ZD152	Double diode pentode	6·3	0·3	g_2	g_1	k	h	h	ap	a'd	a''d	g_3	—	B9A
5V4	Full-wave rectifier	5·0	2·0	—	h	—	a'	—	a''	—	k, h	—	—	K
6AB8	Triode pentode	6·3	0·3	at	gt	k	h	h	ap	g_3	g_2	g_1	—	B9A
6AL5	Double diode	6·3	0·3	k'	a''	h	h	k''	s	a'	—	—	—	B7G

Type	Description	Heater		Pin Connections										Base
		Volts	Amp.	1	2	3	4	5	6	7	8	9	Cap	
6AM6	R.F. pentode	6·3	0·3	g_1	k	h	h	a	s, g_3	g_2	—	—	—	B7G
6AQ5	Output tetrode	6·3	0·45	g_1	k	h	h	a	g_2	g_1	—	—	—	B7G
6AQ8	Double triode	6·3	0·435	a'	g'	k'	h	h	a''	g''	k''	s	—	B9A
6AT6	Double diode triode	6·3	0·3	g	k	h	h	a'd	a''d	at	—	—	—	B7G
6B8	Double diode vari-mu R.F. pentode	6·3	0·3	s	h	ap	a'	a''	g_2	h	g_3	—	g_1	K
6BG6G	Line output tetrode	6·3	0·9	n.c.	h	k	—	g_1	—	h	g_2	—	a	K
6BJ6	Vari-mu R.F. pentode	6·3	0·15	g_1	k	h	h	a	g_2	s, g_3	—	—	—	B7G
6BQ5	Output pentode	6·3	0·76	i.c.	g_1	g_3, k	h	h	i.c.	a	i.c.	g_2	—	B9A
6BQ7	Double triode	6·3	0·4	a''	g''	k''	h	h	a'	g'	k'	s	—	B9A
6BW6	Output tetrode	6·3	0·45	i.c.	g_1	k	h	h	—	a	g_2	g_3	—	B9A
6BW7	R.F. pentode	6·3	0·3	k	g_1	k	h	h	s	a	g_2	g_3	—	B9A
6BX6	R.F. pentode	6·3	0·3	k	g_1	k	h	h	s	a	g_2	g_3	—	B9A
6BY7	Vari-mu R.F. pentode	6·3	0·3	k	g_1	k	h	h	s	a	g_2	g_3	—	B9A
6C12	Triode heptode freq. changer	6·3	0·3	g_2, g_4	g_1	k, s, g_5	h	h	ah	g_3	at	gt	—	B9A
6CD6	Output tetrode	6·3	2·5	—	h	k	—	g_1	—	h	g_2	—	a	K
6CH6	Video output pentode	6·3	0·75	i.c.	g_1	k	h	h	i.c.	a	g_2	g_3	—	B9A
6D1	Diode	6·3	0·15	h	k	h	—	—	—	—	—	—	a	B3G
6D2	Double diode	6·3	0·3	k'	a''	h	h	k''	s	a'	—	—	—	B7G
6D3	Diode	6·3	0·3	a	k	h	h	a	—	—	—	—	—	B7G
6D6	R.F. pentode	6·3	0·3	h	a	g_2	g_3	k	h	—	—	—	g_1	U.X.
6F1	R.F. pentode	6·3	0·35	h	a	s, g_2	g_3	k	g_1	k	h	—	—	B8A
6F6	Output pentode	6·3	0·7	—	h	a	g_2	g_1	—	h	k, g_3	—	—	K
6F12	R.F. pentode	6·3	0·3	g_1	k	h	h	a	s, g_3	g_2	—	—	—	B7G
6F13	R.F. pentode	6·3	0·35	h	a	s	g_3	g_2	g_1	k	h	—	—	B8A
6F14	R.F. pentode	6·3	0·35	h	a	s	g_3	g_2	g_1	k	h	—	—	B8A
6F15	Vari-mu R.F. pentode	6·3	0·2	h	a	s	g_3	g_2	g_1	k	h	—	—	B8A
6F18	Vari-mu R.F. pentode	6·3	0·2	k	g_1	k	h	h	s	a	g_2	g_3	—	B9A
6F19	Vari-mu R.F. pentode	6·3	0·3	k	g_1	k	h	h	s	a	g_2	g_3	—	B9A
6F23	R.F. pentode	6·3	0·3	k	g_1	k	h	h	s	a	g_2	g_3	—	B9A
6F26	R.F. pentode	6·3	0·3	k	g_1	k	h	h	s	a	g_2	g_3	—	B9A
6H6	Double diode °	6·3	0·3	s	h	a'	k'	a''	—	h	k''	—	—	K

° Separate cathodes

Type	Description	Heater		Pin Connections										Base
		Volts	Amp.	1	2	3	4	5	6	7	8	9	Cap	
6J5	Triode	6·3	0·3	s	h	a	—	g	—	h	k	—	—	K
6J7GT	R.F. pentode	6·3	0·3	s	h	a	g_2	g_3	—	h	k	—	g_1	K
6K25	Gas triode	6·3	0·95	s	h	a	—	g	—	h	k	—	—	K
6L1	Double triode	6·3	0·4	h	a'	g'	k'	a''	g''	k''	h	—	—	B8A
6L6	Output tetrode	6·3	0·9	M	h	a	g_2	g_1	—	h	k	—	—	K
6L12	Double triode	6·3	0·45	a''	g''	k''	h	h	a'	g'	k'	s	—	B9A
6L13	Double triode	12·6 c.t.	0·15	a''	g''	k''	h	h	a'	g'	k'	s	—	B9A
6L18	Triode	6·3	0·3	h	a	i.c.	s	i.c.	g	k	h	—	—	B8A
6L19	Double triode	6·3	0·4	h	a'	g'	k'	a''	g''	k''	h	—	—	B8A
6LD20	Double diode triode	6·3	0·25	h	a	g	e	a'_d	a''_d	k	h	—	—	B8A
6P25	Output tetrode	6·3	1·1	M	h	a	g_2	g_1	—	h	k	—	—	K
6P28	Output tetrode	6·3	1·1	—	h	—	g_2	g_1	—	h	k	—	a	K
6SL7	Double triode	6·3	0·3	g'	a'	k'	g''	a''	k''	h	h	—	—	K
6SN7	Double triode	6·3	0·6	g'	a'	k'	g''	a''	k''	h	h	—	—	K
6U4GT	Boost diode	6·3	1·2	—	—	k	—	a	—	h	h	—	—	K
6U8	Triode pentode	6·3	0·45	a_t	g_1	g_2	h	h	a_p	k_p, g_3, s	k_t	g_t	—	B9A
6V4	Full-wave rectifier	6·3	0·6	a'	i.c.	k	h	h	i.c.	a''	i.c.	i.c.	—	B9A
6V6	Output tetrode	6·3	0·45	M	h	a	g_2	g_1	—	h	k	—	—	K
6W2	E.H.T. rectifier	6·3	0·08						Special Base					Spec. 1
6-30L2	Double triode	6·3	0·3	a''	g''	k''	h	h	a'	g'	k'	s	—	B9A
7AN7	Double triode	7·0	0·3	k''	g'', s	a''	h	h	g'	k'_{in}	k'_{out}	a'	—	B9A
7C5	Output tetrode	6·3	0·45	h	a	g_2	—	—	g_1	k	h	—	—	B8G
7K7	Double diode triode	6·3	0·3	h	k_t	a_t	g_t	a'_d	a''_d	s, k_d	h	—	—	B8G
7Y4	Full-wave rectifier	6·3	0·5	h	—	a'	—	—	a''	k	h	—	—	B8G
8A8, 9A8	Triode pentode	9·0	0·3	a_t	g	g_2	h	h	a_p	k_p, g_2	k_t	g_t	—	B9A
8D3	R.F. pentode	6·3	0·3	g_1	k	h	h	a	s, g_3	g_2	—	—	—	B7G
9BW6	Output tetrode	9·0	0·3	i.c.	g_1	k	h	h	—	a	g_2	g_2	—	B9A
9D6	Vari-mu R.F. pentode	6·3	0·2	g_1	k	h	h	a	s, g_3	g_2	—	—	—	B7G
9D7	Vari-mu R.F. pentode	6·3	0·3	k	g,	k	h	h	s	a	g-	g-	—	B9A
9U8	Triode pentode	9·5	0·3	a_t	g_1	g_2	h	h	a_p	k_p, g_3, s	k_t	g_t	—	B9A
10C1	Triode heptode frequency changer	28·0	0·1	h	a_h	a_t	$g_{t, 2}$	$g_{2, 4}$	g_1	k, s	h	—	—	B8A

Type	Description	Heater		Pin Connections										Base
		Volts	Amp.	1	2	3	4	5	6	7	8	9	Cap	
10C2	Frequency changer	28·0	0·1	h	a_h	a_t	g_t	g_2	g_1	k, s, g_3	h	—	—	B7G
10D2	Double diode (separate cathodes)	19·0	0·1	k'	a''	h	h	k''	s	a'	—	—	—	B8A B7G
10F1	R.F. pentode	22·0	0·1	h	a	g_3, s	g_2	k	g_1	k	h	—	—	B8A
10F18	Vari-mu R.F. pentode	13·0	0·1	k	g_1	k	h	h	s	a	g_2	g_3	—	B9A
10L1	V.H.F. triode	19·0	0·1	g_1	k	h	h	k	g_1	a	—	—	—	B9A
10LD11	Double diode triode	15·0	0·1	h	a_t	g	s	a'_d	a''_d	k	h	—	—	B8A
10LD13	Double diode triode	13·0	0·1	a	g	k	h	h	a'_d	s	a''_d	i.c.	—	K
10P13	Output tetrode	40·0	0·1	h	a	i.c.	i.c.	g_2	g_1	k, g_3	h	—	—	B9A
10P14	Output tetrode	40·0	0·1	—	h	a	g_2	g_1	—	h	k	—	—	B9A
12AT7	Double triode	12·6 c.t.	0·15	a'	g'	k'	h	h	a''	g''	k''	htap	—	B9A
12AU7	Double triode	12·6 c.t.	0·15	a'	g'	k'	h	h	a''	g''	k''	htap	—	B9A
12AX7	Double triode	12·6 c.t.	0·15	a''	g''	k''	h	h	a'	g'	k'	htap	—	B9A
12BH7	Double triode	12·6 c.t.	0·3	a'	g'	k'	h	h	a''	g''	k''	htap	—	B9A
16A5	Output pentode	16·5	0·3	—	g_1	k, g_3	h	h	—	a	—	g_2	—	K
16A8	Output pentode with triode (separate cathode)	16·0	0·3	g_t	k_p, g_3, s	g_1	h	h	a_p	g_2	k_t	a_t	—	B9A
17Z3	Boost diode	17·0	0·3	i.c.	i.c.	i.c.	h	h	i.c.	i.c.	i.c.	a	k	B9A
19BG6	Output tetrode	19·0	0·3	—	h	k, g_3	—	g_1	—	h	g_2	—	a	B7G
19Y3	Half-wave rectifier	19·0	0·3	i.c.	i.c.	k	h	h	i.c.	i.c.	i.c.	a	—	B8A
20D1	Double diode	9·5	0·2	k'	a''	h	h	k''	s	a'	—	—	—	B8A
20F2	R.F. pentode	11·0	0·2	h	a	s	g_3	g_2	g_1	k	h	—	—	K
20L1	Double triode	12·6	0·2	h	a'	g'	k'	a''	g''	k''	h	—	—	K
20P1	Line output tetrode	38·0	0·2	—	h	—	g_2	g_1	—	h	k	—	a	K
20P3	Output tetrode	20·0	0·2	—	h	a	g_2	g_1	—	h	k	—	—	B8A
20P4	Line output tetrode	38·0	0·2	—	h	—	g_2	g_1	—	h	k	—	a	B9A
20P5	Output tetrode	20·0	0·2	h	a	i.c.	i.c.	g_2	g_1	k, g_3	h	—	—	K
21A6	Output pentode	21·5	0·3	i.c.	g_1	k	h	h	i.c.	i.c.	g_2	g_1	a	K
21B6	Line output	21·5	0·3	i.c.	g_1	k	h	h	i.c.	i.c.	g_2	g_3	a	B9A
25L6	Output tetrode	25·0	0·3	M	h	a	g_2	g_1	—	h	k	—	—	K
25Z4	Half-wave rectifier	25·0	0·3	—	h	a	—	a	—	h	k	—	—	
27SU	Half-wave rectifier *	13·25 26·5	0·9 0·45	htap	h	—	—	a	—	h	k	—	—	B9A B9A

* Centre-tapped filament or heater

Type	Description	Heater		Pin Connections										Base
		Volts	Amp.	1	2	3	4	5	6	7	8	9	Cap	
30C1	Triode pentode	9·0	0·3	at	g_1	g_2	h	h	ap	k, g_2, s	kt	gt	—	B9A
30C13	Frequency changer	9·0	0·3	k, g_3, s	g_2	ap	h	h	at	gt	k, g_3, s	g_1	—	B9A
30C15	V.H.F. triode pentode freq. changer	9·0	0·3	k, g_2, s	g_2	ap	h	h	at	gt	k, g_3, s	g_1	—	B9A
30F5	R.F. pentode	7·3	0·3	k	g_1	k	h	h	s	a	g_2	g_3	—	B9A
30FL1	Triode output tetrode	9·4	0·3	at	gt	kt	h	h	ap	g_2	g_1	kp, g_2	—	B9A
30L1	Double triode	7·0	0·3	k″	g″, s	a″	h	h	g′	k′in	k′out	a′	—	B9A
30L15	V.H.F. twin triode	7·0	0·3	k″	g″, s	a″	h	h	g′	k′in	k′out	a′	—	B9A
30P4	Output tetrode	25·0	0·3	i.c.	h	i.c.	g_2	g_1	—	h	k, g_3	—	a	K
30P12	Output tetrode	12·6	0·3	i.c.	g_1	k, g_3	h	h	i.c.	a	i.c.	g_2	—	B9A
30P16	Output pentode	16·5	0·3	i.c.	g_1	k, g_3	h	h	i.c.	a	i.c.	g_3	—	B9A
30P18	Frame output pentode	15·0	0·3	i.c.	g_1	k, g_3	h	h	i.c.	a	i.c.	g_2	—	B9A
30PL1	Triode output tetrode	13·0	0·3	at	gt	kt	h	h	ap	kp, g_3	g_2	g_1	—	B9A
30PL13	Frametriodeoutput-tetrode	16·0	0·3	gt	kq, hp, s	g_1	h	h	aq	g_2	kt	at	—	B9A
50CD6	Output tetrode	52·0	0·3	—	h	k, g_3	—	g_1	—	h	g_2	—	a	K
53KU	Full-wave rectifier	5·0	2·8	—	h	—	a′	—	a″	—	k, h	—	—	K
54KU	Full-wave rectifier	5·0	2·3	—	h	—	a′	—	a″	—	k, h	—	—	K
61BT	Output tetrode	6·3	0·7	—	h	—	g_3	g_1	—	h	k	—	—	K
61SPT	R.F. pentode	6·3	1·27	—	h	g_3	g_3	g_1	—	h	k	—	a	K
62BT	Output tetrode	6·3	1·27	—	h	—	g_2	g_1	—	h	k	—	a	K
63SPT	R.F. pentode	6·3	0·3	h	g_3	a	g_3	s	k	g_1	s	h	—	B9G
185BT } 185BTA }	Output tetrode	18·0	0·45	—	h	—	g_2	g_1	—	h	k	—	a	K
807	Output tetrode	6·3	0·9	h	g_3	g_1	k	h	—	—	—	—	a	U.X. 5 pin

TABLE 15.2.—VALVE EQUIVALENTS

Type	Equivalents	Type	Equivalents
AZ31	U143	EZ80	6V4
B36	12SN7GT	FW4–500	U18/20, 451U
B65	6SN7GT	GZ30	R52, 5Z4GT
B152	ECC81, B309, 12AT7	GZ32	5V4G, 54KU
B309	ECC81, 12AT7, B152	HN309	PCL82, 16A8
B319	PCC84, 7AN7, 30L1	HVR2	VLS61
B329	ECC82, 12AU7	KT61	N147, 6AG6G, 6P25
B339	ECC83, 12AX7, 6L13	L63	6J5G
B719	ECC85, 6AQ8, 6L12	LN119	UCL82 (near), 10PL12
B729	6-30L2	LN152	ECL80, 6AB8
D1	T4D	LN309	PCL83
D77	EB91, DD6, 6AL5, 6D2	LZ319	PCF80, 8A8, 9A8, 30C1
D152	EB91, DD6, 6AL5, D77	LZ329	PCF80, 30C1
DD6	D77, EB91, 6AL5, 6D2	N78	6BJ5
DH77	EBC90, 6AT6	N145	10P13
DH719	EABC80, 6AK8, 6LD12, 6T8	N147	6AG6G, EL33
EA50	SD61, 6D1	N150	EL41, 6CK5, 67PT
EABC80	DH719, 6AK8, 6LD12, 6T8	N151	EL42
EAF42	WD150, 6CT7	N152	N359, PL81, 21A6
EB34	6H6GT	N153	N309, PL83, 15A6
EB91	D77, D152, DD6, 6AL5, 6D2	N308	30P4
EBC33	DH63, DH147, OM4, 6Q7G	N309	N153, PL83, 15A6
EBC41	DH150, 6CV7, 6LD3, 62DDT	N329	N154, PL82, 16A5
EBC90	DH77, 6AT6	N339	N152, PL81, 21A6
EBF80	WD709, ZD152, 6N8	N359	PL81, N152, 21A6
EBF89	6DC8, 6FD12	N369	30P12
ECC81	B152, B309, 12AT7	N379	PL84, 15DQ8, 30P18
ECC82	B329, 12AU7	N709	EL84, 6BQ5, 6P15
ECC83	B339, 6L13, 12AX7	N727	EL90, 6AQ5
ECC84	6CW7	OM4	EBC33, DH147, DH63
ECC85	B719, 6AQ8, 6L12	OM6	EF39, W147
ECC91	6J6	OM10	CCH35 or ECH35, X147
ECF80	6BL8	PABC80	9AK8
ECF82	6U8	PCC84	B319, 7AN7, 30L1
ECH35	OM10, X61M, X147	PCC85	9AQ8
ECH42	X150, 6C10, 6CU7, 62TH	PCF80	LZ319, 8A8, 9A8, 30C1
ECL80	6AB8, LN152	PCF82	9U8
ECL82	6BM8	PCL82	HN309, 16A8
EF39	OM6, W147, 6K7GT	PCL83	LN309
EF41	W150, 62VP, 6F15, 6CJ5	PL36	N308, 25E5
EF42	Z150, 6F13 (near)	PL81	N152, 21A6, N359
EF50	63SPT, Z90	PL82	N154, N329, 16A5, 30P16
EF80	Z152, Z719, 6BX6, 6BW7	PL83	N153, N309, 15A6
EF85	W719, 6BY7, 6F19	PL84	N379, 15DQ8, 30P18
EF89	6DA6	PY32	U291
EF91	SP6, Z77, 6AM6, 6F12, 8D3	PY80	U152, U309, 19X3
EF93	W727, 6BA6	PY81	U153, U329 (near), 17Z3
EL33	6AG6G	PY82	U154, U319, 19Y3
EL38	6CN6	PZ30	R14
EL41	N150	R12	EY51, SU61, U43, U151, 6X2
EL42	N151	R16/1T2	1T2, U37
EL81	6CJ6	R52	GZ30, 5Z4GT
EL84	N709, 6BQ5, 6P15	SP6	EF91, Z77, 6AM6, 6F12, 8D3
EL90	N727, 6AQ5	SU61	EY51, R12, U43, U151, 6X2
EL821	6CH6, 7D10	U25	U47
EY51	R12, SU61, U43, U151, 6X2	U26	U49
EY86	6S2	U31	25Z4G
EZ35	U147, 6X5GT	U37	R16, 1T2

Type	*Equivalents*	*Type*	*Equivalents*
U43	EY51, R12, SU61, 6X2	6D2	D77, DD6, EB91, 6AL5
U49	U26	6F6	KT63
U52	5U4G	6F12	EF91, SP6, Z77, 6AM6, 8D3
U143	AZ31	6F18	W739
U145	U404	6F19	EF85, W719, 6BY7
U147	EZ35, U70, 6X5GT	6FD12	EBF89, 6DC8
U151	EY51, R12, SU61, U43, 6X2	6H6	D63
U152	PY80, 19X3, U309	6J5	L63
U153	PY81, U329, 17Z3	6J6	ECC91
U154	PY82, U319, 19Y3	6J7GT	Z63
U192	PY82	6L12	B719, ECC85, 6AQ8
U251	PY81, U329, 17Z3	6L13	B339, ECC83, 12AX7
U291	PY32	6LD12	DH719, EABC80, 6AK8, 6T8
U309	PY80	6P25	KT61
U319	PY82, 19Y3	6SN7GT	B65
U329	PY81, U251, 17Z3	6U8	ECF82
U339	U191	6V4	EZ80
U404	U145	6W2	R12A
UAF42	WD142, 12S7	6–30L2	B729
UBC41	DH118, DH142, 10LD3, 14DDT	7AN7	B319, PCC84, 30L1
UBF80	17C8, 17DDP	7C5	N148
UCC85	B109, 10L14	7Y4	U82
UCH42	X142, 14K7, 14TH	8A8	LZ319, PCF80, 9A8, 30C1
UF41	W142, 12VP	8D3	EF91, SP6, Z77, 6AM6, 6F12
UF42	Z142	9A8	LZ319, PCF80, 8A8, 30C1
UL41	N142, 45A5, 45PT	9D6	EF92, W77, VP6, 6CQ6
UY41	U142, 31SU, 31A3	9U8	PCF82
VLS61	HVR2	10C1	X145
W719	EF85, 6BY7, 6F19	10F1	Z145
W727	EF93, 6BA6	10F18	W119
W729	EF85, 6BY7, 6F19	10LD11	DL145
W739	6F18	10LD13	DH145, UBC81
WD142	UAF42, 12S7	10P13	N145, N118
WD150	EAF42, 6CT7	10P18	N119, UL84
WD709	EBF80, ZD152	12AT7	B309, ECC81, B152
Z63	6J7G	12AU7	B329, ECC82
Z77	EF91, SP6, 6AM6, 6F12, 8D3	12AX7	B339, ECC83, 6L13
Z150	EF42	12SN7GT	B36
Z152	EF80, Z719, 6BX6, 6BW7	15A6	N153, N309, PL83
Z329	30F5	16A5	N154, N329, PL82, 30P16
Z719	EF80, 6BX6, Z152, 6BW7	16A8	PCL82, HN309
ZD152	EBF80, WD709, 6N8	17Z3	PY81, U153, U329
5V4	GZ32	19X3	PY80, U152, U309
6AB8	ECL80, LN152	19Y3	PY82, U154, U319
6AL5	EB91, D77, D152, DD6, 6D2	21A6	N152, N339, N359, PL81
6AK8	DH719, EABC80, 6LD12, 6T8	21B6	PL81 (near)
6AM6	EF91, SP6, Z77, 6F12, 8D3	25L6	KT32
6AQ5	EL90, N727	25Z4	U31
6AQ8	B719, ECC85	30C1	LZ319, PCF80, 8A8, 9A8
6AT6	DH77, EBC90	30F5	Z329
6BA6	EF93, W727	30L1	B319, PCC84, 7AN7
6BW7	8D6	30P4	N308, PL36
6BX6	EF80, Z719, Z152	30P12	N369
6BY7	EF85, W719, 6F19	30P16	N154, N329, PL82, 16A5
6C12	ECH81, X719, 6AJ8	30P18	N379, PL84, 15DQ8, 30P18
6CH6	EL821, 7D10	53KU	GZ37, U54
6D1	EA50, SD61	54KU	GZ32
		63SPT	EF50
		807	QVO5–25

[SECTION 16]

COLOUR CODES

RESISTORS

THE information on resistors given by current colour coding systems includes value, tolerance and grade. These characteristics are indicated either (1) by a series of three or more colour rings which are read from the end of the resistor towards its centre (Fig. 1); or, alternatively, (2) by reading first the body colour; secondly, the tip colour; thirdly, the spot or band colour (Fig. 2). In system (2) the fourth colour (tolerance) is indicated by marking the second tip but, since the colours normally differ from those used to designate value, no confusion is likely to arise.

In each system, the first colour to be read indicates the first figure of the value; the second colour gives the second figure of the value; and the third colour gives the number by which the first two figures should be multiplied in order to arrive at the true value of the resistor. The fourth colour shows the tolerance; the accepted tolerances being ± 1 per cent, ± 2 per cent, ± 5 per cent, ± 10 per cent and ± 20 per cent. Where no tolerance is indicated, it may be assumed that the tolerance is ± 20 per cent.

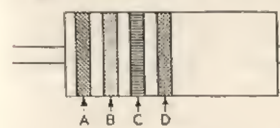


FIG. 1

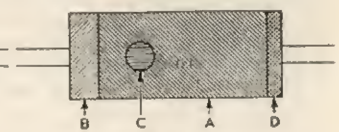


FIG. 2

Colour	*1st Figure (A)*	*2nd Figure (B)*	*Multiplier (C)*	*Tolerance (D)*
Black	—	0	1	—
Brown	1	1	10	±1%
Red	2	2	100	±2%
Orange	3	3	1,000	—
Yellow	4	4	10,000	—
Green	5	5	100,000	—
Blue	6	6	1,000,000	—
Violet	7	7	10,000,000	—
Grey	8	8	100,000,000	—
White	9	9	1000,000,000	—
Gold	—	—	0·1	±5%
Silver	—	—	0·01	±10%
No colour	—	—	—	±20%

Grade 1, high-stability, composition resistors are coded as (1) above, the grade being denoted by either a fifth band of salmon pink, or the body being of that colour.

Examples.—A resistor with a blue body, a grey tip and an orange spot would have a value of 68,000 ohms with a tolerance of ± 20 per cent. The addition of a silver band or tip would indicate a tolerance of ± 10 per cent.

A resistor with four bands of colour, the end one being orange, the next orange, followed by brown and gold would have a value of 330 ohms with a tolerance of ± 5 per cent. In this case the body colour would have no significance, unless salmon pink, which would indicate a Grade 1 resistor.

CONDENSERS

Although many condensers continue to be marked directly with their value and rating, several systems of colour coding are also in use. These differ according to the type of condenser and the extent of the information to be conveyed, though in all cases the same basic code to that used for resistors is adopted, except for the 0·1 and 0·01 multipliers. Information that may be shown by colour coding includes: value, temperature coefficient, tolerance and voltage rating. In addition, the connection to the outer foil of tubular paper condensers may be indicated by a band of colour, usually black, being placed on the casing close to the appropriate connection. All values are colour coded in picofarads (to convert to microfarads divide by 1,000,000).

Ceramic Dielectric.—These have a distinctive end colour, denoting the temperature coefficient, followed by four colour dots, the first dot being that nearest the end colour, the remainder being read in order towards the centre. The tolerance is indicated in percentage for values greater than 10 pF, but directly in picofarads for lesser capacitances.

Colour	*Tip*	*1st Dot*	*2nd Dot*	*3rd Dot*	*4th Dot*	
					Tolerance	
	Temp. Coeff.	*1st Significant Figure*	*2nd Significant Figure*	*Multiplier*	*More than 10 pF.*	*Less than 10 pF.*
Black	NP0	0	0	1	±20%	±2·0 pF.
Brown	N030	1	1	10	± 1%	±0·1 pF.
Red	N080	2	2	100	± 2%	—
Orange	N150	3	3	1,000	± 2·5%	—
Yellow	N220	4	4	10,000	—	—
Green	N330	5	5	—	± 5%	±0·5 pF.
Blue	N470	6	6	—	—	—
Violet	N750	7	7	—	—	—
Grey	P030	8	8	0·01	—	±0·25 pF.
White	P100	9	9	0·1	±10%	±1·0 pF.

Tubular, Metallised-paper.—The values may be colour coded in picofarads, indicated by three dots, having the same significance as in the third, fourth and fifth columns in the table for ceramic dielectric condensers.

Alternative Methods.—While the above systems are those recommended for current usage, several other methods may be met in practice. For example, one colour only may be used to denote tolerance, two colours to denote tolerance and voltage rating, three colours to denote capacitance in picofarads, five colours to denote capacitance in picofarads (first three colours), tolerance (fourth dot) and voltage rating (fifth dot). The order in which the dots are to be read is sometimes indicated by an arrow, but in all cases is from left to right, the first dot being that nearest to one end.

In such instances, tolerance and voltage rating are coded as follows:

Colour	*Tolerance, %*	*Voltage Rating*
Black	—	—
Brown	1	100
Red	2	200
Orange	3	300
Yellow	4	400
Green	5	500
Blue	6	600
Violet	7	700
Grey	8	800
White	9	1000
Silver	10	—
Gold	5	—

Coding of American condensers also differs slightly from that described above: the RMA three-dot code is used for condensers having a tolerance of 20 per cent, the dots indicating the capacitance in picofarads; the RMA six-dot code gives (*top row*) first, second and third significant figures: (*bottom row*) voltage rating, tolerance and decimal multiplier. American fixed ceramic condensers have a broad band followed by four narrow bands or dots giving temperature coefficient, first significant figure, second significant figure, decimal multiplier and tolerance, this system being similar to that described for British condensers of this type. American war-surplus mica and moulded paper condensers are marked according to American War Standards or Joint Army–Navy specifications. These marking are similar in appearance to the RMA six-dot system, but the first dot of the top row indicates type (black/mica, silver/paper), the second and third dots give first and second significant figures, while the bottom row indicates characteristic, tolerance and decimal multiplier.

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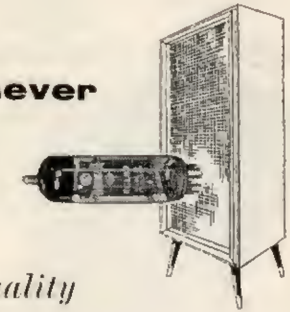

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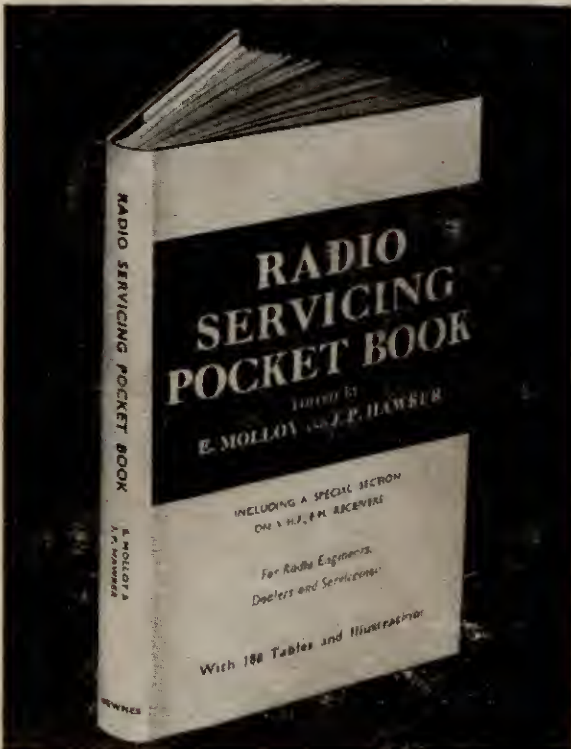

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